NATO
OTAN

Research & Technology Organisation

Annual Report 2011

Published March 2012

Transitioning to a New Science and Technology Organisation for NATO

Foreword

Dr. Robert S. Walker, Ph.D., FCAE
Chairman, Research and Technology Board
North Atlantic Treaty Organisation

Dr. Walker
RTB Chairman

It is my pleasure to introduce you to the 2011 Annual Report of the NATO Research and Technology Organisation, or RTO, NATO's premier forum for Research and Technology (R&T) co-operation among its Member Nations.

This Annual Report also serves as an important instrument for communicating the many significant scientific, technical and managerial accomplishments of the RTO to the NATO community at large.

This past year was very productive for the RTO: it delivered a solid and, indeed its largest ever Programme of Work (PoW) which materialised in a wide variety of activities, all driven by NATO and Nations' priorities. The organisation's leadership also contributed fundamentally to the definition of a way forward for NATO Science and Technology (S&T) Reform and for its implementation – the result of which will be the establishment of a successor organisation – the Science & Technology Organisation (STO) – in 2012.

Inside this Annual Report you will find an overview of the RTO and the many activities executed throughout 2011. The RTO is a unique and dynamic forum, *delivering R&T of high value* to the Nations and NATO. It is also the largest organisation of its kind in the world, with thousands of scientists, engineers, administrators and managers taking advantage of the fact that the RTO is an effective and proven forum for Nations to leverage their respective R&T programmes. They also benefit from the fact that the RTO helps build coherence and synergy among the Nations' R&T investments and develops R&T capabilities in areas critical to the Nations and NATO.

Since the inception of the RTO in 1998, the strategic environment has evolved significantly, as reflected in the New Strategic Concept for NATO. In the Fall of 2010, the RTO's governing body, the Research and Technology Board (RTB) recognised the need to adapt to this current environment and address the austerity being faced by the Nations. At the same time, a NATO Reform Agenda, both profound and ambitious, was launched at the Lisbon Summit in order to achieve the dual objectives of making NATO more effective and more affordable. All this led to the RTB recommending to NATO leadership that an S&T Reform be launched.

At the March 2011 Ministerial meeting, Ministers tasked the North Atlantic Council (NAC) to prepare a plan for S&T Reform, building on ideas advocated by the RTB. In June 2011, Ministers formally agreed to proceed with a NATO S&T Reform and provided guidance on the expected outcomes.

I was pleased and honoured that the Council tasked me, as the RTB Chairman, to define and lead the execution of an S&T Reform Implementation Plan. An implementation team was established, which was composed of representatives from the entire NATO S&T community and staff from both Nations and NATO, and which met all expected deliverables, including a draft Charter for the STO.

March 2012 will see the end of my three-year tenure as RTB Chairman. I am both pleased and proud to know that the way has been paved for the transition of the RTO into the STO, which has been positioned for success under new leadership. I am confident that the STO will meet the expectations for which it was designed – to enhance the contribution of S&T in affecting the decision-making of the Nations and NATO at strategic, operational and tactical levels that delivers mission success, identifies sound policy and strategy, informs balance-of-investment choices for new or improved capabilities and that builds enduring partnerships beyond current NATO membership which contributes to confidence, stability and security. The STO will also focus on NATO policy and strategy priorities consistent with the Secretary General's "Smart Defence" concept, whereby Nations working together within the NATO framework can achieve their national objectives at reduced cost.

NATO's scientific community is on the verge of implementing an important reform, and in so doing, will better position NATO S&T as a strategic enabler of the knowledge and technology advantage of the defence and security postures of the Nations and NATO in the true spirit of Theodore von Kármán, who was the impetus behind NATO's co-operative research efforts.

I wish all of you success in your future endeavours, and most of all, I wish the STO fair winds and following seas.

The RTA, Serving the Nations and NATO

MGen. Albert Husniaux
Director, NATO Research and Technology Agency
North Atlantic Treaty Organisation

MGen. Husniaux
RTA Director

The important commitment of the Nations and NATO to the RTO's Programme of Work testifies to the value that Nations and NATO place on the co-operative research and network of experts that comprise the RTO. As a forum where Nations can pursue their common defence research interests, the RTO provides an effective framework for the Nations to leverage their respective R&T programmes, contribute to the development of R&T capabilities in areas critical to the Nations and NATO, their R&T workforce, their tools, ideas and networks, and finally, help build coherence and synergy among the Nations' R&T investments and between the needs of the Nations and NATO.

The RTO, the RTA and their successors will continue to promote and foster not only a broad network of scientists and engineers from NATO Nations, but also an ever-growing group of experts from Partner Nations. Given the universal language of science and the rapid globalisation of threats, the RTO – and its successor, the Science and Technology Organisation – will continue to provide an excellent forum for engaging the security and defence science and technology communities of peace-seeking Nations to improve the mutual understanding of not just science and technologies, but also of cultures and values.

More than 3,000 technical experts, scientists and engineers from the Nations have been involved in the activities of the RTO on a voluntary basis, either executing the PoW or providing leadership and guidance at the various levels of the RTO.

These highly esteemed volunteers are able to rely on the permanent staff of the executive arm of the RTO, the Research and Technology Agency (RTA), located in Neuilly-sur-Seine (FRA), which is composed of NATO staff and highly qualified experts provided by the Nations. The RTA creates the fertile environment that makes the effective execution of the RTO's technical programme possible. It serves as an interface between the scientific community of the Nations and the military of NATO, and constitutes the central node of the NATO R&T network, managing scientific and technological knowledge exchange, facilitating all RTO activities, and providing support whenever and wherever it is needed.

In 2011, the RTA continued to improve on its ability to provide executive support to the RTO network as well as to other Alliance bodies requiring assistance. To that extent, the RTA continued to enhance its collaborative working environment, simplifying and extending the use of existing on-line workspaces, not only to the benefit of the RTO and its members, but also to the benefit of other NATO bodies and organisations, relying on the excellence of the RTA to deliver the collaborative environment needed to implement their activities.

2011 has been, without any doubt, one of the busiest years ever seen by the RTA. In addition to providing executive support to the largest ever RTO PoW, the RTA also provided executive support to all the RTB initiatives pertaining to the S&T Reform and to the definition of a new supply/demand relationship with all the stakeholders, thereby playing an instrumental role in the implementation of the S&T Reform, which was led by the RTB Chairman.

2012 will be an even more challenging year with the RTA transitioning its functions to the STO by 1 July 2012. While remaining in the familiar Neuilly-sur-Seine environment and by focusing even more so on its activities on the support to the RTO technical Panels and Group, it will see its tasks and structure evolve significantly.

I am confident that the hard work carried out by the RTA Staff in the preparation, definition and implementation of the S&T Reform will contribute significantly to a smooth transition into this new organisation.

For more detailed information on the RTO and the activities composing the programme of work, please visit the RTO website (www.rto.nato.int) or contact us by email at mailbox@rta.nato.int.

This Annual Report is the first of its kind. It merges what used to be the RTO brochure, documenting the RTO and its programme of work and the yearly report of the RTO. We invite you to read it, to hear about the highlights of 2011, including examples from the PoW, and to learn more about the role and the organisation of the RTO, its community of interest and the RTA.

EXECUTIVE SUMMARY

The Annual Report that follows provides an overview of NATO's Research and Technology Organisation's structure, function and technical portfolio, and the 2011 events, efforts, facts and figures for consideration by the Military Committee (MC), Conference of National Armaments Directors (CNAD) and NAC. RTO efforts in 2011 included an all-time high number of technical activities as well as preparations to implement a new Science and Technology Organisation in 2012.

The RTB strategic goals and priorities continue to be refined and revised through extensive consultations with senior leadership from NATO and the Nations. This process ensures that the RTO continues to align NATO R&T in response to NATO and Nations' priorities, the results of which can be viewed in this document from multiple perspectives.

In response to the NATO Reform, during 2012 the RTO will transition to a new Science and Technology Organisation which will include the transfer of functions from the current RTA, and the establishment of the first NATO Chief Scientist and his office within the NATO HQ. The new STO will also include the NATO Undersea Research Centre as a key element within the organisation. A new S&T Strategy for this reformed environment will be developed to enhance the capabilities of NATO, the Nations and Partners.

Part 1 of this Annual Report serves to acquaint the reader with the mission and organisational elements that facilitate the co-operative R&T described here, addressing agreed-upon priorities. Activities undertaken in response to the NATO Agencies Reform decision are also described.

Part 2 of this Annual Report then offers examples of work completed in 2011, grouped by militarily relevant research thrusts, with contributions from the RTO Panels and Group. These NATO S&T thrusts address interoperability, innovative solutions, transitioning technologies, disruptive technologies, providing advice, force generation, capability development and threat mitigation.

Part 3 of this Annual Report provides a more technically explicit description of the Panels and Group activities including the scope, PoW and selected highlights of the past year. This approach, organising PoW results by the expertise field clearly demonstrates how the exchange of knowledge, methods and tools which occur in the execution of their PoW facilitates the maintenance of technological excellence across the Alliance. In this part of the Annual Report, technological excellence is acknowledged, by mentioning our finest – the recipients of the Theodore von Kármán Medal and the Scientific Achievement Award, presented to those national technical experts who have been instrumental in advancing knowledge within the NATO S&T community.

Part 4 of this Annual Report is dedicated to the assessment of performance. It contains feedback from stakeholders who have been solicited for their perspectives on the RTO contributions which have impacted their core business. They provide clear testimonies on the value of NATO S&T, both from a Nations' and a NATO perspective.

The final part of the Annual Report, Part 5, contains the yearly report elements pertaining to the financial and human resources required to enable the RTO co-operative environment and to deliver NATO collaborative S&T.

TABLE OF CONTENTS

The Mission

The RTO promotes and conducts co-operative research and information exchange, develops and maintains a long-term NATO R&T Strategy, and provides guidance and advice to all elements of NATO and the Nations on R&T issues.

The Organisation

The RTO has a legacy of co-operative defence R&T that dates back to the mid-1950s and Dr. von Kármán's efforts to promote collaborative work amongst the NATO Nations, formed in 1998 by the merger of the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). The RTO reports to both CNAD and the MC; it has a governing board and Technical Panels, and it integrates the research and technical missions of its predecessors.

In pursuit of its mission, the RTO operates on three levels – RTB, Technical Panels and Technical Teams – and is supported in its efforts by an executive agency, the RTA. Fig. 1 illustrates the RTO reporting chain, the hierarchy of the three operating levels, and the support role of the RTA.

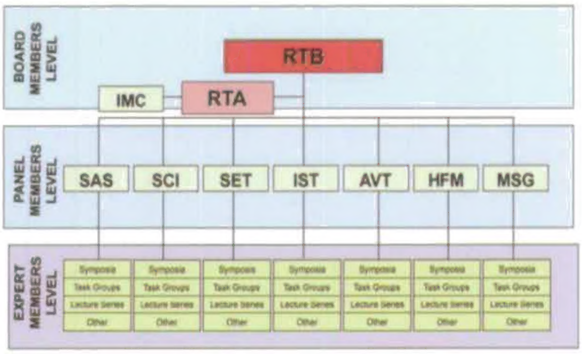

Figure 1: RTO Organisation.

The Research and Technology Board constitutes the highest authority in the RTO. It is the policy body tasked by the NAC, through the CNAD and MC (see Fig. 2), to serve as the single integrating body within NATO responsible for the direction and/or co-ordination of defence R&T.

Its membership is comprised of up to three leading personalities in defence R&T from each NATO Nation. The members are chosen by the Nations and may be from government, academia or industry. Typically, Board members are senior S&T executives at the deputy under-secretary, deputy assistant secretary or deputy administrator level.

The RTB also has ex-officio members from Allied Command Transformation (ACT), NATO C3 Agency (NC3A), Main Armaments Groups (MAGs), NATO Industrial Advisory Group (NIAG), NATO Undersea Research Centre (NURC) and from the Science for Peace and Security Programme (SPSP). The Chairman of the RTB is a senior member of the Board, elected by the national members for a three-year term. Each Nation also appoints a National Co-ordinator to administer its RTO activities.

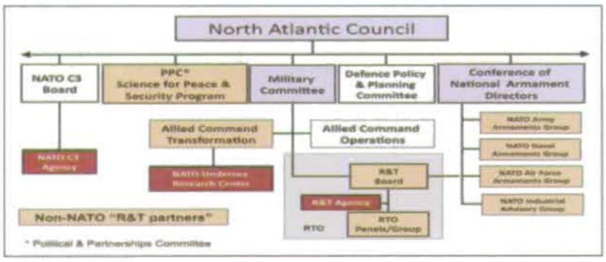

Figure 2: RTO in the NATO Structure.

Technical Panels, Group and Committee – The total spectrum of R&T activities is addressed by six Technical Panels who manage a wide range of scientific research activities, a Group specialising in modelling and simulation, and a Committee dedicated to supporting the information management needs of the organisation.

AVT	Applied Vehicle Technology Panel
HFM	Human Factors and Medicine Panel
IST	Information Systems Technology Panel
SAS	System Analysis and Studies Panel
SCI	Systems Concepts and Integration Panel
SET	Sensors and Electronics Technology Panel
NMSG	NATO Modelling and Simulation Group
IMC	Information Management Committee

These Panels and Group are the power-house of the RTO and are made up of national representatives as well as recognised world-class scientists, engineers and information specialists. In addition to providing critical technical oversight, they also provide a communication link to military users and other NATO bodies.

The scientific and technological work of the RTO is carried out by Technical Teams, created under one or more of these eight bodies, for specific research activities which have a defined duration. These research activities can take a variety of forms, including Task Groups, Workshops, Symposia, Specialists' Meetings, Lecture Series and Technical Courses.

In any given year, there are approximately 140 research activities being conducted by these Technical Teams. In all cases, these activities result in the publication of highly valued scientific literature published by the RTO. The results of the RTO's research can also be found in some specific peer-review journals.

An abstract of every publication can be viewed on the RTO website (www.rto.nato.int). Depending on their classification, the full text of many of these reports can be

downloaded. CD-Rom copies may also be obtained from one of the National Distribution Centres or can be purchased from one of the RTA Sales Agencies, details of which can be found on the website.

The RTO actively supports NATO's Partnership for Peace (PfP) and Mediterranean Dialogue (MD) participation. Each year, the RTO seeks to increase the number of activities open to PfP and MD Nations, and additionally sponsors specific plenary sessions of Board and Panel meetings for these non-NATO Nations. For example, in the 2011 PoW, approximately 75% of the new activities were open to PfP Nations and 30% were open to MD Nations. The RTO also extends opportunities for collaborative research to its Global Partners and opened approximately 50% of the 2011 activities to these Nations.

Research and Technology Agency (RTA) – Facilitating the RTO's co-operative efforts is the job of the RTA. This small executive agency, located near Paris in Neuilly-sur-Seine (FRA), has approximately 30 NATO civilian staff, and in addition, twenty military and civilian personnel generously provided by Member Nations, who serve on limited duration rotations.

In its role as facilitator, the RTA provides programme management assistance to the RTO Panels, serves as an interface between the national scientific and NATO military communities and provides R&T knowledge management through its website and databases.

NATO R&T Strategy: Strategic Goals and Priorities

The R&T Strategy for NATO, formally approved by the NAC in November 2005, is a top-level strategy document which identifies goals and objectives for all the NATO organisations involved in R&T. This document applies globally to all NATO R&T organisations and provides basic guidance on how they should function in support of the Member Nations and the Alliance.

The five strategic goals of the RTO identified in this Strategy are to:

1) Align NATO R&T to the NATO priorities of transformation and the security environment, in co-operation with the MC and the CNAD;
2) Establish effective NATO R&T co-ordination through clear and evident leadership;
3) Provide best advice on present and future needs;
4) Improve the exploitation and dissemination of R&T; and
5) Create the most effective and enabling R&T collaborative environment.

These goals, as well as the supporting actions identified in the Strategy, provide context for specific objectives within the RTO Rolling Plan. In response to the NATO S&T Reform, the STO will develop a new Charter and corresponding S&T Strategy will be developed in 2012 for approval by the North Atlantic Council. This strategy will provide greater efficiencies and effectiveness to maximise the co-operative S&T environment and the S&T communities.

RTO Rolling Plan

One of the responsibilities of the RTB is to establish a long-term RTO Rolling Plan, based upon the operational requirements of the NATO Commanders and the demands of the Nations. This Rolling Plan describes the priorities and projected actions required for the formulation of the R&T programme. The 'rolling' nature of the plan refers to the periodic revision of RTO objectives based on changing requirements, the changing strategic environment and new developments in technology. Each year, the RTO Rolling Plan is updated to reflect current critical requirements and RTB decisions.

RTB Priorities

A practical approach was determined in order to establish **NATO RTB Priorities**, linked to the policy, capability and operational imperatives of the Nations and NATO that will support all NATO R&T Strategy Goals. Its first iteration was approved by the RTB at the Spring 2009 Executive Session and has been subsequently refined and revised as the result of extensive consultations with Board members, RTO Panel/Group Chairs and stakeholder NATO senior leaders.

On a yearly basis, the RTB defines its priorities, consisting of both management (key initiatives) and R&T Priorities.

RTB Key Initiatives (management priorities) are intended to institutionalise the processes, mechanisms and relationships required to ensure that the NATO RTO and the RTB successfully meet their strategic goals. These initiatives are addressed at the RTB level, with support from the RTA and sub-groups of the Board such as its Strategy Implementation Sub-Group, and the Finance and Audit Committee.

The Key Initiatives are divided into five categories – listed in the order of the potential significance of their impact:

1) Implementing NATO S&T Reform;
2) Addressing S&T Critical Policy Challenges (in 2011 some were addressed via one-day roundtables organised in the margins of RTB meetings);
3) Strengthening Relationships (in 2011 strategic partnerships with targeted Partners were addressed, in order to have more effective and efficient S&T co-operation with non-NATO Nations contributing to NATO current operations);
4) Implementing RTB Strategic Assessment; and
5) Adjusting RTB Modus Operandi.

Figure 3: Identifying S&T Critical Policy Challenges.

Various initiatives were taken by the RTB to address all key initiatives. They all were framed in the overarching context of NATO S&T that constituted, along with the delivery of the PoW, the main 2011 focus. Hence these initiatives are described at the end of this section, devoted to the NATO Reforms.

RTB S&T Priorities (scientific/technological/analytical) are intended to guide the PoWs of the RTO Panels and Group.

These priorities are based on the national and NATO S&T challenges required to support existing and future NATO operations throughout the world. The identification of RTB S&T Priorities is also a mechanism for extending the Board's indirect effect on national S&T programmes.

These S&T Priorities, by their nature, are challenging areas of S&T development and hence may be enduring. The evolution of these priorities over time may be due to a combination of the progress realised and the changing emphasis in the drivers for priority setting.

RTB S&T Priorities consist of the following elements:

1) Long-Term Capability Requirements (LTCRs);
2) RTB S&T Hard Problems (STHPs); and
3) Emerging/Emerged Disruptive Technologies (E2DTs).

The NATO R&T Strategy Goal #1 and its associated Rolling Plan objective have led the RTO to focus on the 38 LTCRs that were released by the ACT in 2008.

The RTO exercises leadership for seven of the NATO LTCRs and has a supporting role in the other 31 LTCRs.

Table 1: The List of CNAD's LTCRs Assigned the RTO Leadership.

NATO LTCR	LTCR Definition	Panel/Group Linkage	NATO LTCR	LTCR Definition	Panel/Group Linkage
9	Capable of countering an Improvised Explosive Device (IED) threat at any point in the life-cycle	**SET (Lead)** AVT/IST/SAS/SCI (Support)	31	Capable of planning and decision support to improve feedback to decision-makers and other staff	**SAS (Lead)** HFM/IST/NMSG (Support)
19	Capable of increasing the performance and endurance of personnel during operations	**HFM (Lead)** AVT/SET (Support)	34	Capable of preserving space as a sanctuary for NATO assets	**SCI (Lead)** AVT/SET (Support)
20	Capable of realistic computer modelling and simulation to support military operations, training, experimentation, decision-making and comprehensive planning	**NMSG (Lead)**	37	Capable of building a holistic knowledge base of the operational environment and identifying the strengths, vulnerabilities and potential behaviour of a potential adversary	**SAS (Lead)** HFM/IST (Support)
28	Capable of providing real-time audio and textual language translation to overcome language and communication barriers	**IST (Lead)** HFM (Support)			

Table 2: The List of RTB S&T Hard Problems (STHPs).

STHP #	RTB STHPs	Lead RTO Panel/Group	STHP #	RTB STHPs	Lead RTO Panel/Group
1	Minimise fratricide and collateral damage in joint fires	SCI	8	Defeat the CBRNE terrorist threat	HFM
2	Achieve asymmetric advantage by small unit operations	–	9	Protect critical information infrastructure	IST
3	Enable command interoperability	IST	10	Deliver persistent Intelligence, Surveillance and Reconnaissance (ISR) in a counter-insurgency/ counter-terrorism context	SCI
4	Prepare and sustain the Force	HFM	11	Support a comprehensive approach which minimises use of force	SAS
5	Advance capabilities to conduct/ influence information operations	SAS	12	Integrate autonomous intelligent systems into the battlespace	SCI
6	Reduce the burden on the dismounted soldier	HFM	13	Find 'greener' solutions to address environmental pressures	AVT
7	Improve air assets survivability	AVT	14	Mitigate strategic resource (particularly energy) scarcity	AVT

RTB STHPs are high-visibility, high-impact S&T Priorities on which the RTB has decided to concentrate attention. These priorities address problematic gaps in the collective knowledge and technology base of NATO where progress is deemed to be particularly critical to NATO's future. These priorities, originally established in 2010, have been reviewed by the Board as well as the RTO Panels/Group and updated accordingly. There were 14 RTB STHPs in the 2011 release of the Board's priorities. Each was intended to result in advances in knowledge and technology that contribute to the objectives presented in the table above.

RTB E2DTs are technologies which are either disruptive or deemed to be potentially disruptive, either from the opportunity they present to the Alliance or from the threat they pose in the hands of potential adversaries. The nature of the disruptive effect may not yet be fully identified. An important aspect of RTO co-operation in E2DTs is to explore and identify innovative applications of emerging or (partially) emerged technologies, which when coupled with changes in tactics and procedures, could result in a significantly improved military advantage either for NATO forces or provide an advantage for potential adversaries.

Table 3: The List of 18 RTB Emerging/ Emerged Disruptive Technologies (E2DTs).

E2DT #	RTB E2DTs	Lead Panel/ Group	E2DT #	RTB E2DTs	Lead Panel/ Group
1	Quantum capabilities	IST	10	Technologies for non-conventional weapons	SCI
2	Cloud computing and virtualisation	IST	11	Smart materials	AVT
3	Autonomous intelligent technologies	SCI	12	Nano-robotics (molecular-based nanotechnology)	AVT
4	Ubiquitous wireless networking technologies	IST	13	Power sources and storage	AVT
5	Sensing technologies (hyper-spectral, terahertz)	SET	14	Biology-based solutions (bio-metrics, Bio-mimetics, bio-signatures)	HFM
6	Low-cost night vision (solid-state silicon technology at room temperature)	SET	15	Medical advances from biological sciences	HFM
7	Directed-energy technologies	SCI	16	Internet-enabled social networking	HFM
8	Micro-satellites	SCI	17	Hypersonic vehicles and propulsion	AVT
9	Virtual and augmented reality and cognitive interfaces	NMSG	18	Stealth/counter-stealth technologies	AVT

RTO Contribution to Building the Future of NATO S&T

Preamble: The LISBON Summit

Agencies Reform – Reform of the S&T Function

At the Lisbon Summit, 19-20 November 2010, Heads of State approved the Agencies Reform initiative, which proposed the consolidation and rationalisation of the functions and programmes of the existing 14 NATO agencies into three.

Following the Summit, NATO's S&T function emerged as a specific area for reform stretching beyond the initial objective to improve NATO R&T co-ordination. The primary impetus for this new focus was the findings and recommendations of the NATO R&T Co-ordination Study (RTCS) delivered by the RTB and discussed with the Nations in 2010. This study provided extensive analysis to support a set of recommendations pertaining to the NATO S&T mission, accountabilities and governance, structures, business model savings and re-investment, and provided the ground-work and the principles for the Reform of the S&T function.

S&T Reform: Spring 2011 Ministerial

Creation of the New Science and Technology Organisation

In June 2011, Ministers of the NATO Nations approved the creation of a new NATO subsidiary body, the NATO STO, to be established by 1 July 2012. They also approved the creation of a Chief Scientist position, supported by an office of the Chief Scientist, both located at NATO Headquarters (HQ). As part of this decision, the Ministers also directed the future NATO Chief Scientist to develop a NATO S&T Strategy, define a process for a Strategic Assessment, and assess the potential need for a NATO Operational Research and Analysis programme.

Responding to NATO S&T Reform: 2011 Key Initiatives

In response to the NATO Reform direction provided by the Nations at the Lisbon Summit, the RTB defined 2011 management priorities (key initiatives). These 2011 key initiatives offered several opportunities to consult with both national and NATO representatives on how best to structure and deliver an optimised S&T business model, while simultaneously ensuring a high-quality execution of the current PoW.

The RTB Priorities Workshop

Within the framework of the RTB, a Priorities Workshop took place 18-19 January 2011 at the RTA. Led by the RTB Chairman, it was attended by more than 40 participants from the NATO S&T Community, including ACT, NC3A, NURC as well as NATO HQ representatives from Defence Investment (DI) and Emerging Security Challenges (ESC) Divisions. The RTB Chairman, RTB Strategy Implementation Sub-Group Members, the RTA Director, experts from the RTO Panels/Group and RTA staff discussed the implementation of a number of changes to the current NATO S&T accountabilities, governance, structures and business models through which a proposed NATO S&T framework will be operationalised.

The objectives were to inform the community of the collective response to the R&T Co-ordination Study questionnaire, provide an analysis of the results and identify options to move forward. A roundtable discussion served to share views on practical approaches to reach a successful implementation of the NATO S&T Reform. The roundtable discussion captured a wide variety of issues and concerns regarding the implementation of the consolidated recommendations. The notion of knowledge brokering and its importance as a core competency was also discussed, which addressed elements of information management, dissemination, storage, etc., with a complex linkage and interdependence across the NATO S&T.

An analysis of today's evolving environment and its drivers was made, noting that innovation provided via S&T is critical to successfully address national and NATO priorities linked to policy, capability and operational imperatives of the Nations and NATO. To support discussions, the new NATO Strategic Concept, the Emerging Security Challenges Division's and ACT's perspective on these Priorities, the Joint Operations 2030 (SAS-066) results and Panel/Group Chairs' perspectives were provided.

The participants of the Workshop expressed views on a practical approach to establish these priorities. It was generally agreed that concurrence from all stakeholders including the new Agencies and the ESC Division will be needed. The emphasis on responding to both current military priorities was seen as too short term, addressing immediate operational requirements and failing to address a more comprehensive approach to include security and longer term concerns, which was seen as a necessary approach as priorities evolve. Inclusion of all Nations in this process and attention to protecting high-value efforts was also recommended.

The core message arising from the Workshop was that the evolution of RTB priorities into NATO S&T Priorities should occur, and that this initiative be more than a rebranding of the current RTB priorities.

A Strategy Implementation Sub-Group (SISG) meeting on 20 January analysed the results of the Workshop. This led to a revised set of recommendations and a mandate to launch the S&T Reform that was presented to the Spring 2011 RTB Strategic Planning Session and subsequently the RTB Executive Session.

NDPP R&T Planning Domain Workshop

A Workshop on the R&T Planning Domain of the NATO Defence Planning Process (NDPP) was held at the RTA, 16 March 2011. Representatives from NATO HQ, ACT (Long-Term Requirements and Future Solutions Branches), ACT/SEE (Mid-Term Requirements and Defence Planning Implementation), NC3A, NURC and RTA Staff attended the one-day staff-to-staff meeting.

The goal of the Workshop was to address the possible contribution that the NATO S&T community could provide across the several steps of the NDPP. The outcome of this extremely fruitful Workshop resulted in the identification of the major players of the R&T Planning Domain, the definition of the co-ordination measures among them, the identification of the potential R&T inputs on various NDPP products, and the identification of the practical approaches, meeting opportunities, procedures and working methods to interact with the Planning community.

The outcome and the way-forward to address the NDPP R&T Planning Domain were presented at the 2011 Spring and Fall Executive Sessions of the RTB, who endorsed the proposed approach.

Figure 4: The NATO Defence Planning Process.

NATO S&T Reform Implementation Team – Inaugural Meeting and Workshop

At their meeting on 8-9 June 2011, Defence Ministers agreed to implement a NATO Agencies Reform and approved its Implementation Plan that included the way ahead for the NATO S&T Reform.

The Work Plan for the implementation of NATO Agencies Reform specified that the RTB Chairman, supported by the Directors of NURC and the RTA, should prepare a Work Plan for implementing S&T Reform, thereby preparing the groundwork for the formal establishment of the STO.

To support the RTB Chairman in carrying out his responsibilities, the S&T Reform Implementation Team (RIT) was established under the leadership of the RTB Chairman, closely co-ordinating with the Chairman of the Defence Policy and Planning Committee (Reinforced) NATO Agencies Reform (DPPC(R)AR) and the Leader of the Change Management Support Team.

The S&T RIT held its inaugural meeting 1-2 September 2011 at the RTA, with the mission of supporting the Change Management Support Team at NATO HQ, undertaking all actions necessary to execute a work plan endorsed by the DPPC(R)AR.

During the first meeting, the Modus Operandi and expected deliverables of the RIT's work were discussed and agreed upon.

The Cyber Security Roundtable

Top executives of NATO, NATO Nations and Partner Nations in charge of defining and implementing NATO's co-operative research and technology efforts attended the S&T policy level Cyber Security Roundtable meeting organised during the RTB Fall 2011 and held in Sofia (BUL). This event was used as a forum to find ways of furthering the science-policy dialogue on cyber security – an important priority for NATO and the RTO.

The purpose of this Cyber Security Roundtable was to:

- Provide an informative discussion on the dimensions of cyber security;
- Help identify how the NATO S&T community can contribute to the cyber security challenges;
- Explore the concept of 'Knowledge Brokering', involving the RTB members; and
- Determine how this RTO and S&T event can help to contribute to the policy and operations of other bodies of NATO.

The outcome of the roundtable discussions were essentially that:

- On the technical front, the ever-increasing sophistication of threats and concepts of operations was recognised as a great challenge;
- A multi-dimensional approach, involving policy, legal aspects, human rights, international co-operation and public/private sector partnership was called for;
- National and international agencies need linkages between technology and multi-dimensional aspects of the issue;
- NATO is a forum of choice to gather all interested parties to find solutions; and
- The NATO S&T community will contribute to that effort using such efficient roundtables and the knowledge brokering concept.

The NATO S&T Roundtable

On 1 November 2011 at his headquarters in Norfolk (USA), the Supreme Allied Commander Transformation (SACT), General Stephane Abrial, hosted a senior delegation of NATO and Nations' scientific leaders led by Dr. Walker, the Chairman of the RTB.

The roundtable discussion that ensued focused on how to design appropriate interfaces to ensure a balance between the 'supply' of S&T capacity that will be provided by Nations through the future NATO STO and the 'demand' for multi-national S&T efforts originating from NATO and the Nations.

In his introductory remarks, General Abrial explained:

> *"... in the wake of the June 8 Defence Ministerial decision to reform NATO S&T, we are here together to consolidate foundations for a new, inclusive relationship between scientific knowledge users and science producers, between demand and supply in the Alliance".*

In his response, Dr. Walker indicated that:

> *"S&T is the engine of innovation providing not only a technology advantage but also a knowledge advantage, which is all about people. The relationship between demand and supply should move from 'hand-off' to 'hand-shake'. The focus shall be on alignment, on knowledge brokering of co-operative investment, supporting the 'Smart Defence' concept of the NATO Secretary General. This will ensure that S&T is appropriately positioned to be a strategic enabler of the knowledge and technology advantage of the Nations' and NATO's defence and security posture".*

The Roundtable proved to be a very successful event in developing a closer relationship between HQ SACT and the NATO S&T community. The discussions provided a basis for the future implementation of a NATO S&T framework that can do more to focus Nations' scientific efforts on addressing the emerging challenges and needs of the Alliance as a whole.

Guidance from this Roundtable will be used to establish the STO and its interfaces with customers.

Figure 5: Attendees of the S&T Roundtable at HQ SACT Norfolk (USA).

The RTB Extraordinary Session

In order to progress with the implementation of the NATO S&T Reform, an Extraordinary Session of the RTB was convened on 12-13 December 2011 at the RTA. A large part of the Session was devoted to the STO Charter development in order to have it delivered to NATO HQ by the end of 2011. In addition, the RTB approved to recommend for nomination as the first Chief Scientist, the current RTA Director, Major-General Albert Husniaux (BEL).

The future edition of the RTB Priorities, as well as expectations when organising (Panels/Group) as well as hosting RTO activities by the Nations – and the RTB meetings in particular – were also addressed. The Session was followed by an S&T RIT meeting during which the draft STO Charter was further fine-tuned.

A Holistic Approach to Warfighter Needs

RTO's collaborative R&T has taken a holistic approach to addressing warfighter needs, providing a comprehensive portfolio of activities which include:

- Contributing to interoperability solutions and facilitating international synergies (through STANAG development);
- Generating and exploring innovative system solutions;
- Assessing, maturing, demonstrating, positioning and transitioning technologies required for defence and security;
- Anticipating, assessing and giving advice on the implications of emerging and potentially disruptive technologies;
- Providing knowledge, analysis and advice to support decision-making and policy development;
- Informing military force generation and employment;
- Supporting capability development processes; and
- Contributing to confidence building and threat mitigation to address important security needs.

These needs are responded to by the Nations co-operative efforts in the Research Thrusts section which follows.

CONTRIBUTING TO INTEROPERABILITY SOLUTIONS AND STANDARDISATION

Qualification and Structural Design Guidelines for Military UAVs (AVT-174)

The political arena is swiftly changing. Military requirements differ significantly now from what they were a decade ago. To meet the new and ever-changing demands in a timely fashion, the time required to develop new weapon systems needs to be considerably reduced. The need to bring new affordable and reliable weapon systems on-line rapidly requires a quick and thorough assessment of the design space. Within AVT-145 a Workshop was conducted to assess the current situation for design criteria for unmanned air vehicles. An outcome of this Workshop was the recommendation to form a focused activity (AVT-174) on the development of guidelines for this class of air vehicles.

Unmanned Air Vehicles (UAVs) cover a broader range of the flight spectrum than manned vehicles – many are much smaller and some have endurance that exceeds man's capabilities (see Fig. 6). Applying traditional manned qualification processes to these vehicles can penalise the capabilities of autonomously controlled vehicles that respond to perturbances in the flight regime more than fifty times as fast as humans. To apply conventional qualification approaches to the very small aircraft coming onto the scene now is simply not justified for cost or in recognition of the flight regime in which such aircraft fly.

To develop a set of qualification guidelines that can extend across the panorama of flight from vehicles weighing grams to those crossing the sky at re-entry velocities, from vertical take-off and landing vehicles to vehicles that remain airborne for weeks at a time, has proven a challenge. In order to not over-penalise these vehicles with legacy standards but still provide the level of safety expected for flight vehicles in today's environment, it was necessary to seek the key parameters of flight and interpret them in new ways.

In recognition of the progression of many of these vehicles from demonstrator – to limited operations – to fully operational vehicles, a series of guidelines were developed that progress through these stages in development and build on the qualification tests of previous stages so that none need to be repeated and all contribute to the full qualification of the vehicle when it is accepted into fully operational flight.

This AVT activity was established to recommend a set of guidelines for design criteria and structural qualification for unmanned air vehicles tailored to reduce the level of effort required, specifically the testing requirements.

The guidelines were intended to cover the integration of three sets of topics as they apply to unmanned air vehicle/ weapon system design and qualification:

1) General UAV design requirements;
2) Structural design guidelines; and
3) Validation approaches.

Structural design guidelines include: loads, static strength, factors of safety, structural health and event monitoring, stiffness – aeroelasticity, durability, producibility and maintainability (reparability and inspectability), damage tolerance, discreet events, fail safety and crashworthiness.

Validation approaches include:

- Conventional qualification practices;
- Qualification by analysis;
- The use of flight and ground tests;
- Spiral development as a qualification concept;
- Prototype flight qualification;
- Hybrid structural concepts; and
- Dealing with non-conformance issues.

These guidelines for the design and qualification of UAVs are intended to provide a solid technical foundation for the development of qualification criteria by the Armed Forces of Member Nations. They should provide a common framework for such criteria, and since they are grounded in fundamental science, engineering and experience associated with the development of military UAVs, they should provide a more definitive and less costly structure for the design, development and operation of such UAVs in the future.

This activity provides the following benefits to the military services of NATO:

1) A solid technical foundation for qualification criteria for both fixed-wing and rotary-wing UAVs;
2) Consistent guidelines across a wider breadth of aircraft size, speed, weight and payload lethality than manned aircraft will ever have to cover; and
3) Cost savings from a set of guidelines that allows progression from prototype – to limited operational vehicles – to fully qualified vehicles that does not duplicate testing from one single step of the progression to another, but builds toward eventual full qualification of the aircraft.

To provide these benefits, an all encompassing set of guidelines was developed that covers the entire range of aircraft weights, speeds and operating environments (see Fig. 7).

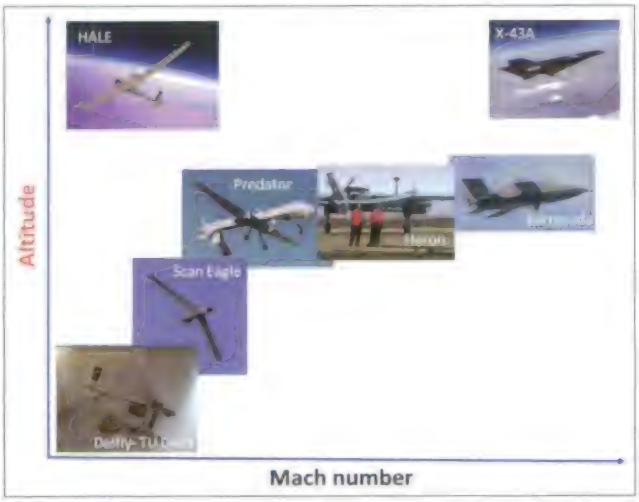

Figure 6: UAVs Cover a Broader Range of Flight Conditions than Manned Vehicles.

Vehicle Type	Existing Regulatory Guidance (Reference Only)	General Guidance	International Aerospace	National Aerospace	DoD Airspace		
		Max Energy mv^2	Sovereign	FAA Class A, B, C, D, E, G	Non-Expendable UAV Restricted to Combat Zones	Restricted Areas & Combat Zones	Expendable/ Prototype UAV Restricted to Range
Med/Large Fixed Wing	STANAG 4671 JSSG 2006	mv^2 > (1320 lbs) (200 kts)^2 mv^2 > (600 kg) (370 km/h)^2	1	1	1	1R	1P
Med/Large Rotary Wing	Part 27, 29		1	1	1	1R	1P
Light, F/W & R/W	AC 23-19A	mv^2 < (1320 lbs) (200 kts)^2 mv^2 < (600 kg) (370 km/h)^2	2	2	2	2R	2P
Small / Mini / Micro F/W & R/W	Association of Model Aeronautics (AMA)	mv^2 < (20 lbs) (120 kts)^2 mv^2 < (9 kg) (190 km/h)^2	3	3	3	3	3

Figure 7: AVT-174 UAV Categories are Related to Ground Fatalities from In-Flight Failures.

C2 Architectures for Operations with Manned and Unmanned Air Vehicles (SCI-186)

The subject for this study is command and control architectures for unmanned and manned aircraft conducting missions collaboratively in the same airspace. The purpose of the study was to expand on the work done by SCI-124, creating more detailed architectures, developing a more comprehensive list of measures of merit, further assessing the impact of UAVs on The NATO Air Command and Control System (NACCS), and finally suggesting potential developments for relevant STANAGs. Special attention was paid to the recent work done by SAS-050 and SAS-065 in order to supplement this Task Group's work on command and control approaches and capability modelling.

The results of this activity include a report and an architecture model which was developed according to the NATO Architecture Framework (NAF) using two well-known architecture modelling tools. The SCI-186 Task Group has identified new Contingency Operations (CONOPS), drafted a capability model (including taxonomy and dependencies), node definitions and relationships, information model and functional allocations.

The Task Group also came up with a future concept in which local multi-vehicle collaboration exploiting flexible automation reduces the requirement for long-range communications. A diverse selection of unmanned aircraft (very small to very large, low cost to high cost) have been proposed for extensive use in both Intelligence Surveillance and Reconnaissance (ISR), weapons employment and decision-making – with manned aircraft often being 'pulled back' to a predominantly command and control role with intermittent direct combat involvement with UAV support.

Applications of Service Orientation (SoA) in tactical air operations should be studied further, as it is a potential enabler of greater interoperability between diverse Partner Nations. Further work is recommended to use simulations and workshops actively as an aid for multi-disciplinary discussions and architecture evaluations.

NACCS is considered to be of little relevance to the tactical level command and control which we have dealt with. If further study on the possible effects of unmanned aircraft on NACCS development is desired, it must be conducted by/within the NACCS organisation or sub-contractors with full access to detailed information.

Semi-automated sensor data exploitation and decision-making, ad-hoc dynamic communications networks, human-machine collaboration and ethics are important subjects for further study. Ethics is an important topic, for example in relation to how much and how (un)reliable automation may be acceptable in different contexts. Ethical issues have also been a central focus for this Task Group, as ethics is strongly related to autonomy, which heavily affects possible Command and Control (C2) solutions.

Should such application indeed be desirable in the future, NATO must provide further guidance on the application of its architecture framework (NAF) to such efforts. Active use of the NAF is deemed to be a promising aid in bringing together the plethora of actors involved in defining future NATO architectures and CONOPS, both in a limited air power scope and in the ever-more important joint, combined and civil-military collaborative reality.

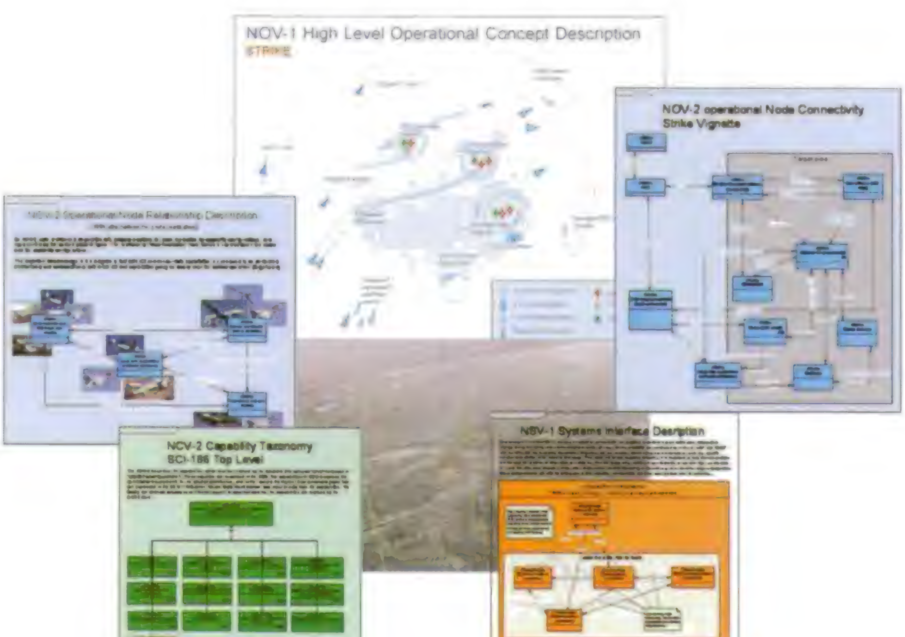

Figure 8: Some of the NATO Architecture Framework (NAFv3) Products Developed by SCI-186, Describing a Concept and Architecture for Future Collaborative Manned-Unmanned Air Vehicle Operations.

Simulation Interoperability (MSG-086)

Achievement of interoperability and reuse of simulations are among the major objectives of the NATO Modelling & Simulation Master Plan. In 2009, the RTO Exploratory Team ET-027 was established with the intention of analysing Modelling & Simulation (M&S) interoperability issues identified by participating Nations. Surprisingly, 63 issues were identified, and consequently, recognised as constraints limiting interoperability in the M&S domain.

In 2010, MSG-086 was tasked with analysing the interoperability issues identified by ET-027 in order to recommend or prototype Distributed Simulation Engineering and Execution Process (DSEEP) products to mitigate or obviate the issues.

MSG-086 classified and allocated these identified issues into the following groups and categories, assigning responsibility for each group, and agreeing upon content and format for documenting analysis and recommendations regarding each group:

- Conceptual model;
- Scenario;
- Fidelity/aggregation;
- Synthetic environment;
- Infrastructure and tools;
- Federation development;
- Legacy systems;
- LVC-Interoperability;
- C2-Sim-coupling;
- Time management;
- Security; and
- Organisational aspects.

Up until now (utilising the available standards), 'true' simulation interoperability in terms of logically consistent networked simulation applications has not been achievable.

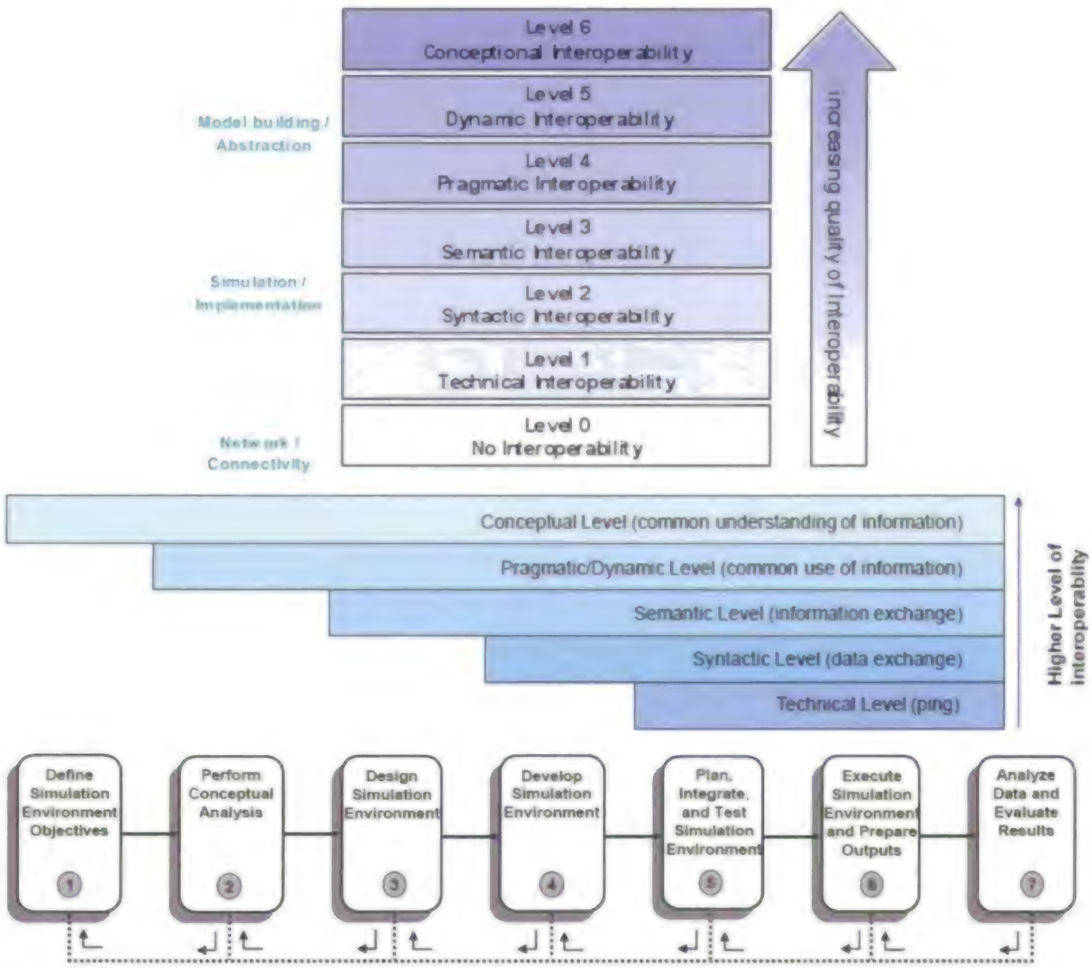

Figure 9: Simulation Interoperability Mapped to DSEEP[1].

[1] "Ontology Driven Interoperability – M&S Applications", Whitepaper for Inter-service/Industry Training, Simulation, and Education Conference (I/ITSEC).

The focus of the present standards for networked simulation applications is basically on the technical, syntactic and (to a limited extent) on the semantic interoperability level. For simplification (decrease of time and costs for experts meetings, special agreements, special bridging and middleware developments) and automatisation of the development of future networked simulation applications, interoperability at higher levels (pragmatic, dynamic, conceptual) is required (see Fig. 9 on the previous page for an overview of the levels of interoperability).

This in turn requires standardisation of information products from a suitable simulation development and execution process (e.g., from the DSEEP: Distributed Simulation Engineering and Execution Process). Such standards should be related to the modelling domain in contrast to present simulation interoperability standards.

In terms of interoperability, the main objectives for the RTO Task Group MSG-086 are directed towards:

- Obtaining a common understanding of aspects related to the different levels of interoperability;
- Proposing the content and structure of required information products and determining the relationship between these information products (as described, for example, in the DSEEP process description to support interoperability at all levels); and
- Understanding the development of these information products by providing proto-types.

GENERATING AND EXPLORING INNOVATIVE SYSTEM SOLUTIONS

Benefits and Barriers for Emerging Small-Scale Electrical Power Sources (AVT-165)

The requirement for increased quantities of electrical power is common to many military applications, including dismounted soldier systems and unmanned land, sea and air vehicles. For example, there is an ever-increasing need for soldiers to carry electronic equipment, such as night-vision goggles and laser range-finders. Since these applications are mobile, there is a requirement for portable power sources to have high-energy density to avoid overburdening the soldier with many, or heavy, power sources on long missions – the dismounted soldiers of most Nations routinely carry 50 kg or more of equipment, a significant portion of which can be batteries.

AVT-165 has been working to review the state-of-the-art portable advanced batteries, fuel cells and combustion engines up to the size of 300 W, as well as the possible application of supercapacitors. The desire has been to identify where these technologies are heading and highlight the Research & Development (R&D) that must be completed to realise the benefits, as there have been repeated claims in the media of breakthroughs in battery energy storage that have proven to be highly exaggerated.

Apart from the basic properties of the power sources, it is also important to understand the durability and safety aspects in the field – fuel cells are air breathing so they can be affected by dusty conditions or the catalyst can be degraded by chemical poisons such as sulphurous gases.

With regards to durability, the portable fuel cells that are currently available run on hydrogen, methanol or propane, which means that a new fuel type has been introduced to the logistics chain. The military would prefer a fuel cell that runs on existing logistic fuels, so this is one area of R&D that should be pursued. Fuel cells can provide a weight advantage over batteries for missions of duration over 24h, depending on the power draw. Small internal combustion engines currently being developed are not as efficient as their larger counterparts, but they do provide a relatively simple means of generating power.

In terms of safety, there have been many instances of lithium-ion batteries catching fire. This usually happens because of over-charging, but can also be because of defective materials. All types of lithium battery contain flammable electrolytes, in contrast to the aqueous systems such as nickel-metal hydride. Consequently, safety is an aspect that was considered by the Task Group, particularly for the soldier in the field where a battery pack can be penetrated by a bullet. Some lithium battery types are much more reactive to bullet penetration than others. Bullet penetration is an issue for the fuel tanks of the other power sources and reactivity depends on the type of fuel.

Figure 10: Left – 50 W Reformed-Methanol Fuel Cell Being Used to Recharge a BB-390 Battery (the beige portion of the fuel cell is the fuel canister); Right – Demonstration Solid Oxide Fuel Cell System Designed for 20 W Over 96 Hours.

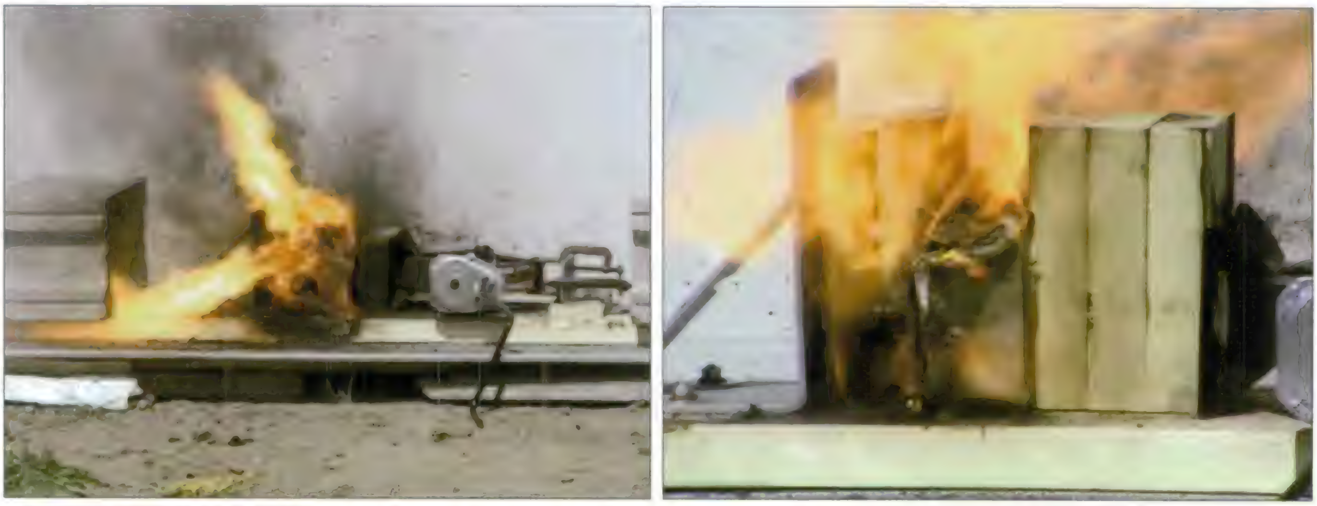

Figure 11: Comparison of the Flames Produced After Bullet Penetration of a BB-2590 Lithium-Ion Battery Containing Cylindrical Cells (left) and a BB-3590 Battery Containing Pouch Cells (the BB-2590 fire is far more violent).

Besides energy storage capacity, other important issues include cost, logistics and signature. Non-rechargeable lithium batteries and AA-sized alkaline cells are inexpensive, but are a huge logistics burden. Replacement with rechargeable batteries would reduce this burden and expense, but the recharging infrastructure needs to be in place.

Fuel cells are still very expensive and their initial use is likely to be as field chargers for batteries. Microturbines, reciprocating engines and thermoelectric generators may be simpler and less expensive than fuel cells, but their efficiencies are lower, so they require more fuel.

A further key finding of the Task Group has been the confirmation of low thermal signature possible even if the power source operates internally at high temperature.

The AVT-165 Task Group has investigated the benefits and barriers of all of these power sources and the findings should be of practical value to military planners. Overall, new, emerging or improved power technologies can make the dismounted soldier a more effective warfighter by maintaining lethality, situational awareness and communication with colleagues for longer times, but without adversely affecting mobility. The benefits of unmanned vehicles can also be enhanced.

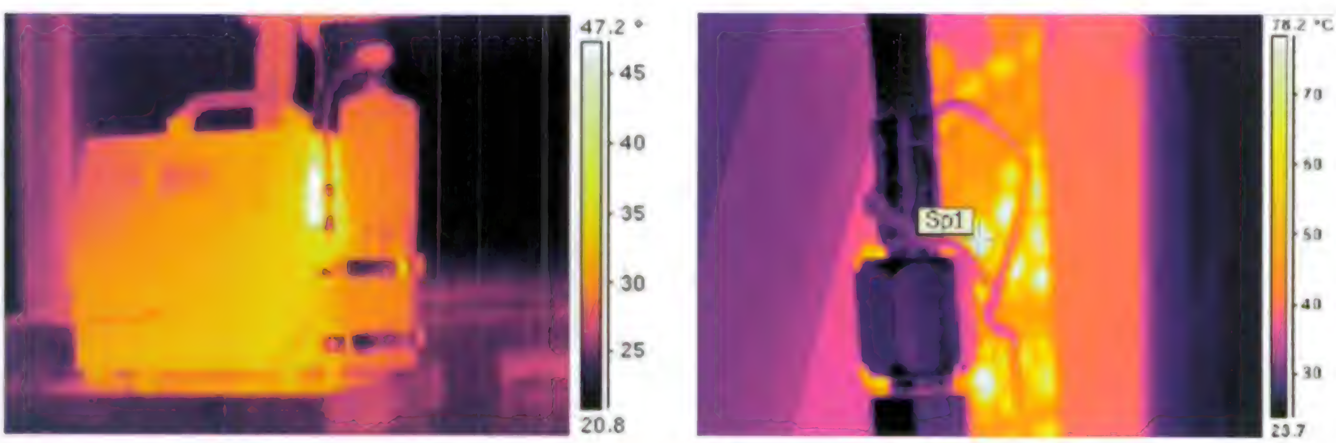

Figure 12: Thermal Image of a Solid Oxide Fuel Cell System (left) and Close Up of the Exhaust Grille (right).

Rotary-Wing Brownout Mitigation: Technologies and Training (HFM-162)

The HFM-162 Rotary-Wing Brownout Mitigation Task Group was formed to examine the effects of Rotary-Wing Brownout (RWB) and whiteout on pilots during operations. Brownout is the condition developed by re-circulating rotor downwash as a helicopter lands or takes off in an arid or a snowy (whiteout) environment. The dust, dirt, or snow that is developed by the downwash renders out-the-cockpit visibility severely degraded or non-existent.

The resultant mishaps due to the Degraded Visual Environment (DVE) are a serious problem and Partner Nations report losses of aircraft and personnel. RWB is a $100M/yr loss for the US Services alone. Nearly 1000 US services helicopters (1985 – 2005) have been lost or damaged and RWB landings are the overall largest cause of Rotary-Wing (RW) airframe loss in the US Services. Canada, France, Germany, Israel, the Netherlands and the United Kingdom have also reported significant losses due to RWB. Sweden and Norway have reported whiteout mishaps.

This study was undertaken to investigate the incidence and severity of the problem faced by Partner Nations, to examine and document current and planned technology developments, and to evaluate and document the brownout training procedures within NATO.

To provide a true, multi-purpose helicopter sensor, the Task Group members concluded that LADAR (Laser Detection and Ranging) technology can provide an effective system to see through the brownout. Intuitive hovering and landing cockpit display symbology employed in a guidance landing system must also be an integral part of an effective system for DVE landings.

The most innovative system solution the Task Group explored combines a 3-D imaging sensor with landing guidance algorithms nested in an intuitive symbology set (see Fig. 13 below). This scanning laser sensor (LADAR) is capable of rendering high-resolution images of the landing zone and then intuitively displaying these images to the pilot during brownout landings. This highly detailed imagery is then overlaid with the Brownout Symbology System (BOSS) developed by the US Army.

Researchers then developed robust landing guidance algorithms that are capable of directing the pilot all the way to touchdown (when a planned landing point has been designated). This symbology was then augmented to reduce clutter, eliminate scaling changes and provide guidance cues driven by the landing algorithms. One symbol provides cueing for the cyclic control (right hand), while the other provides cues for the collective (left hand).

These innovations have been demonstrated successfully in-flight and are now being developed for installation in RW aircraft.

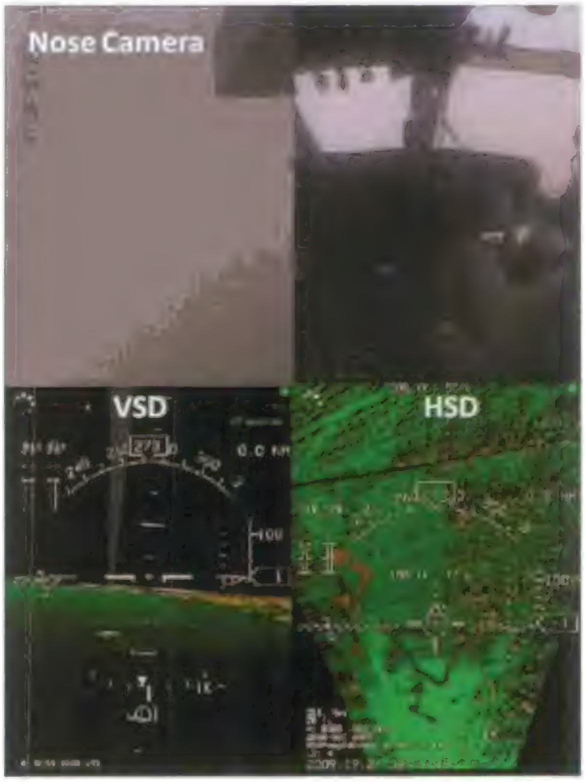

Figure 13: Helicopter Nose Camera View of Brownout Landing with No Visibility (top). Vertical (VSD) and Horizontal Situation Displays of LADAR Imagery with Symbology Overlaid

ASSESSING, MATURING, DEMONSTRATING, POSITIONING AND TRANSITIONING TECHNOLOGIES REQUIRED FOR DEFENCE AND SECURITY

Smart Textiles for the NATO Warfighter (SET-109)

The militaries of NATO Nations are always seeking to improve the combat effectiveness of their soldiers. In response to interest by the NATO Army Armaments Group (NAAG), the SET-109 Task Group was formed to investigate materials and structures that can be used for combat clothing and equipment that sense and provide feedback about environmental conditions and that respond and/or are activated to perform specific functions.

This activity investigated a number of materials, ranging from basic fibre technologies (still in development) to commercially available systems, identified the state-of-the-art in smart textile systems, and developed and tested such textiles for the following applications:

- Photovoltaic (PV) textiles for storing and distributing solar energy;
- Electronic elements integrated in textiles for power and data transmission;
- Sensors embedded in garments for physiological health monitoring of the soldier;
- Antimicrobial textiles for protection against bacterial attacks; and
- Protection against bullets.

For PV textiles, different models were tested in laboratories and in different locations and latitudes (Afghanistan, Norway) under a variety of conditions and temperatures. Norwegian researchers evaluated a number of commercially available PV prototype technologies, among them a portable 48-W amorphous silicon solar charger purchased from Bren-Tronics Inc. and a portable 62-W CIGS (Copper-Indium-Gallium-Slenide) based solar charger purchased from UnatSolar.

Figure 14: Bren-Tronics Amorphous Silicon-Based Charger.

In one set of tests, the Bren-Tronics charger (see Fig. 14) was mounted on a roof and intensively tested in Oslo (NOR) (60°N latitude), from December 2005 to November 2007. This solar panel array yielded up to 38 W of power and an energy of about 200 – 250 Wh/day in March on sunny days. In contrast, only 50 – 80 Wh/day was produced on sunny days in January. After three to four months, a gradual reduction in the power from the panel was observed. After 12 months, the maximum power decreased from 38 W to 8 W, and the maximum daily energy production decreased from 250 Wh to about 50 Wh, an output reduction of roughly 80%. Similarly, the CIGS-based panel was tested on a roof in Kabul (AFG) (35.5°N latitude), from January to March of 2009 and stored up to 45 W of power and an energy of about 250 Wh/day on sunny days in January and March.

Based on such extended tests, PV technology is assessed to be mature for military applications, but reduction in performance should be expected after several months of intensive use. Photovoltaic textiles represent a power source that is self-contained, silent, extremely long-lived and readily scaled to smaller sizes. These properties make PV technology very appealing for distributed low-power applications like powering soldier-borne sensors embedded in textiles.

In addressing the power and data transmission aspect, an advanced prototype of a smart combat uniform was designed, fabricated and finally tested by Canada (in a snow trial in February 2010, under an applied industrial project). One of the objectives of the trial was to evaluate whether a wired cloth in functional mode operating some accessories would affect a camouflage signature. A Global Positioning System (GPS) unit, a keyboard and a power pack were attached to the uniforms by Velcro, and the fully loaded uniform was observed with Infra-Red (IR) cameras at a stand-off distance of 20 meters. As neither heating of the textile nor changes in the infra-red signature were observed, the IR camouflage signature was unaffected.

Equally interesting results were achieved for the other smart textile applications, therefore smart textiles represent a new family of textile structures which can fulfil not only the requirements of the next-generation advanced military warrior, but also public-safety needs in civilian environments. Clearly, smart textiles can be applied to battlefield dress, shirts, pants, footwear, head-gear, shin-surface protection and eye protection.

While the results of this Task Group show significant promise, they have been tested for one-function use only – thus the feasibility of multi-functional use remains an open research question. The extent to which smart textiles will be implemented in military environs may well depend on their ability to provide multiple simultaneous functions. Addressing this question requires further research and development.

Next-Generation Electronic Warfare (SCI-234)

The SCI-234 Electronic Warfare (EW) Specialist Working Group was created to bring together the technology needed to address the evolving capability gaps presently being independently addressed by many of the NATO Nations.

The Working Group sought to address the following issues:

- Identify potential future NATO EW capabilities and the technology to address fast-evolving threats;
- Explore hardware/software architectures, real-time data transport, interoperability, operational concepts and training, and sharing of Electronic Sensor (ES) data; and
- Define directions for future NATO EW research.

NATO Nations developed and fielded a vast EW capability to address the Soviet threat; however world events have changed not only the threat, but also what is needed to address present and future threats, which could span from non-NATO Nations using asymmetric warfare to warfare between multiple coalitions of NATO Nations. The key question that is being asked by NATO EW research organisation is, "What is the next generation of EW systems that can address a broad spectrum of future threats and what are the technology gaps that must be addressed?"

At a Workshop held in June 2011 in Amsterdam (NLD), over 30 technical presentations were given addressing these issues – three over-arching priorities were identified:

1) The Interoperability of EW to EW and EW to Command, Control, Communications, Computer, Intelligence, Surveillance and Reconnaissance (C4ISR) systems;
2) The assessment and recommendation of updates to STANAGs for EW data structures; and
3) The assessment of open software/hardware architecture to improve response time to threats, system availability and to reduce logistic costs.

In both present and future NATO warfare, EW and C4ISR must operate with a minimum of electromagnetic interference to each other. Commanders want a Common Operating Picture (COP) down to the company and platoon levels. A NATO STANAG defining a common EW data structure will be a key enabler.

Finally, the rate of new commercial technology introduction and its use by NATO Nations makes the old classically closed proprietary architectures of weapon systems and its long development, replacement and training ineffective. The next-generation military systems will require a new approach that can provide new and shorter capability updates.

Six new EW Technical Activity Proposals (TAPs) are being defined to begin addressing some of the most critical gaps.

These consist of:

- TAP 1: Operational Assessment of Real-Time Geolocation Algorithms for Enhanced Situational Awareness (SA);
- TAP 2: EW Planning and Management Tool;
- TAP 3: Platform-Level EW Architectures for Joint/Coalition Operations;
- TAP 4: Distributed EW Architectures for Joint/Coalition Operations;
- TAP 5: Concepts for NATO Cyber and EW Operations; and
- TAP 6: Scientific Support to Maritime EW Trials (MCG8).

From a combat user's standpoint, the present EW capability gaps for a Brigade Combat Team (BCT) are:

- Joint Electronic Attack (EA) assets lack the capacity (low density / high demand) and specific capability to meet BCT requirements.
- Rapid fielding of BCT EW systems have saved lives, but lack of integration results in electronic fratricide and compatibility is a systemic issue.
- Control of EW is not integrated with BCT mission command systems.

Fig. 15 below depicts an integrated air, ground and naval integrated EW capability with annotated supporting TAPs. It is hoped that sufficient NATO Nations, including Coalition Partners like Australia and New Zealand, will participate in follow-on activities so all six proposed TAPs can be initiated.

Figure 15: Net-Enabled EW Across NATO Forces.

Support to the World's Biggest International M&S Training and Education Conferences ITSEC & ITEC (MSG-083)

Since the NMSG was created in 1998 and integrated in the NATO RTO structure, it was given the mandate to internationally promote the work being carried out by NATO and its members in the training and education domains of M&S. The benefits from this approach are two-fold:

1) Make the NMSG and by extension the RTO visible to the international M&S community; and equally as important
2) Keep up-to-date with leading-edge technology and current tendencies in M&S.

The goal envisioned is simple – use M&S to improve the efficacy and efficiency of those NATO-wide activities which can significantly benefit from the better employment of the 'always limited' scarce available resources: time, funds, manpower. M&S provides the appropriate framework to overcome these limitations, to minimise its negative effects and to optimise the use of resources.

RTO's NATO Modelling & Simulation Co-ordination Office (MSCO) leads the NATO effort in organising the NATO participation in the two international Training & Education Conferences on M&S: I/ITSEC (Interservice/Industry Training, Simulation & Education Conference), held in Orlando (USA) and ITEC (International Training & Education Conference), in Europe at alternating venues – ITEC 2012 will be held in London (GBR).

The experience gathered by the NMSG community after more than ten years of continued presence has recently transformed the initial expectations from a mere passive presence focused on absorbing concepts, tendencies and technologies, into an active role utilising these opportunities as the most cost-effective means to promote the work of the NMSG, the RTO, and by extension, the whole NATO organisation.

Aligned with this idea, it is not surprising that there has been a dramatic increase in number of RTO Technical Activities organised in conjunction with these events, and not only purely under the umbrella of the RTO NMSG, but also expanding to embrace co-operation with other RTO Panels, such as Human Factors and Medicine (HFM) and System Analysis and Studies (SAS).

During ITSEC 2011 (29 November – 2 December), the NMSG organised more activities than ever before during a single event – the following are worth mentioning:

- RTO Workshop on the NATO M&S Master Plan Update (MSG-084).
- Six RTO Task Group Meetings: MSG-073/MSG-085/MSG-098/MSG-099/MSG-100/MSG-106.
- RTO Specialist Team on "Co-operation NMSG – NATO M&S Centre of Excellence" (MSG-103).
- RTO Specialist Team on "Definition the Support to Exercises with Distributed Simulations and Tools" (MSG-105/MSG-106).
- RTO Workshop on "Simulation in Support of Current NATO-Led Operations" (MSG-104).
- RTO Inter-Panel Workshop MSG-SAS-HFM on "Human Behaviour Modelling for Military Training Applications" (MSG-107).

Figure 16: RTO's NMSG Booth Transformed into a Multi-Functional Platform Open to Co-operative Demonstrations of Technologies, Workshops, Task Group and Specialist Team Meetings and Exchange of Information with Experts and the General Public.

ANTICIPATING, ASSESSING AND GIVING ADVICE ON THE IMPLICATIONS OF EMERGING AND POTENTIALLY DISRUPTIVE TECHNOLOGIES

ANTICIPATING, ASSESSING AND GIVING ADVICE ON THE IMPLICATIONS OF EMERGING AND POTENTIALLY DISRUPTIVE TECHNOLOGIES

Emerged/Emerging 'Disruptive' Technologies (E2DTs) are technologies which are either disruptive, or deemed to be potentially disruptive because of the profound impact they may have on capabilities in business sector(s), whether military or civil, or both.

Using a sporting metaphor, it is the potential to provide a game winning step change either from the opportunity it presents for obtaining a competitive edge or from the threat it poses by placing an edge in the hands of the competitors. In the NATO military context, the aim is for the Alliance to exploit the opportunity and be ready to defeat the threat so as to gain and maintain a winning edge over its current adversaries or potential adversaries in the future.

The nature of the disruptive effect may not yet be fully identified. Nor with certainty the identification of the emerged/emerging technologies that are most likely to be disruptive. Hence it is a complex problem space where the capability to identify the right technologies that will have the right disruptive effect offers a superior advantage over ones adversaries and have profound impact on military operations.

In this context, the Information Systems and Technology Panel organised a Symposium, held in Madrid (ESP) 9-10 May 2011, that had two specifics aims:

1) To expose methods, tools and techniques which can be applied to identify the emergent technologies that can be used to explore the space and identify with a degree of scientific rigor the E2DTs with the potential to impact future military information systems.
2) To identify innovative applications of these emerging or (partially) emerged technologies which, when coupled with changes in tactics and procedures, could result in significantly improved military advantage either for NATO forces or could provide advantage to potential adversaries.

The wide set of disciplines encompassed within the theme of the Symposium allowed a spread of topics which was reflected in the programme and presented during the Symposium. The disciplines included:

- Quantum capabilities;
- Autonomous intelligent technologies;
- Ubiquitous mobile wireless networking technologies;
- Virtual and augmented reality and cognitive interfaces;
- Biology-based solutions;
- Internet-enabled social networking;
- Networks as complex adaptive systems and their visualisation; and
- Hyper-computing.

The presentations and discussions confirmed that investigations must be conducted across the spectrum of interests since a small perturbation in a technology or discipline could have a profound impact on behaviour and system outcomes – hence the diversity of subjects and styles.

Figure 17: Scientists/Experts Attending the Symposium at the CEntro Superior de Estudios de la DEfensa Nacional (CESEDEN).

High-Power Microwaves and Directed-Energy Weapons (SCI-232)

A Symposium on "High-Power Microwaves and Directed-Energy Weapons" was held in conjunction with the SCI Panel Business Meeting in Norfolk (USA), 9-10 May 2011. The Symposium was a timely opportunity for individuals, (both military and civilian) from government and industrial defence organisations across NATO to interact on Directed-Energy (DE) topics. As expected, colleagues from different Nations also took advantage of the setting to initiate informal discussions and meetings in order to make plans for future collaborative activities.

The main purpose of the Symposium was to attract and involve a wider audience of technical experts, decision-makers and people with expertise in other fields. Another purpose was to provide a forum for the exchange of information on Radio Frequency Weapons (RFW) between NATO members, as well as assisting in providing a common RFW picture for NATO.

Radio Frequency Directed-Energy Weapons (RF DEW) may be used to degrade the operation of equipment or to cause

permanent damage. As transmitter capabilities have developed, NATO is starting to consider whether the increasingly higher transmitter powers currently available could be used to defeat critical NATO systems. RF DEW is receiving increased attention from NATO members; consequently their decision-makers need an appreciation of both defensive and offensive applications.

Figure 18: DEW Network Display.

The Symposium was proposed and organised by the SCI-198 Task Group on "Protection of Military Networks Against High-Power Microwave Attacks" and provided a forum for out-briefing the results of SCI-198. In addition, it was an opportunity to review results from the SCI-227 Specialist Team on "Directed-Energy Weapons (DEW) Related Capabilities: Near-, Mid- and Long-Term Prospects". SCI-227 was established in 2009 following a request by NATO Air Force Armament Group (NAFAG) to RTO.

The SCI-198 briefs covered susceptibility testing of NATO tactical computer networks, identifying potential susceptibilities and ways to harden the networks. In addition, RF DEW detection techniques were addressed. The SCI-227 presentation examined the current capabilities for developing directed-energy weapons applications and linked these capabilities to technology needs identified by NATO. Other topics were also presented, including a summary of RTO high-power RF activities, source development efforts, vehicle stopping, sensor technology, calculation of electromagnetic fields and the DE threat.

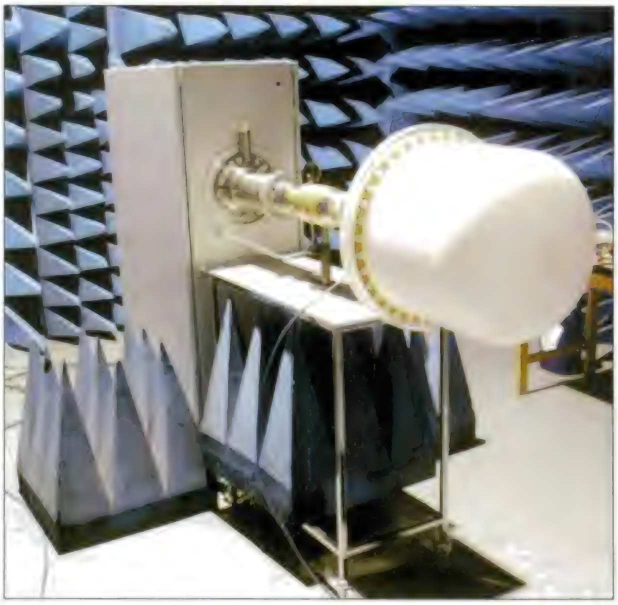

Figure 19: Directed-Energy Weapon Testing.

The Symposium arrived at several key recommendations. The increasing vulnerability of commercial and military networks calls for an overall NATO strategy on RF DEW. Similarly, information sharing is needed for establishing a better overview of these new technologies and the prospects for future NATO capabilities. It was therefore recommended that efforts be initiated to improve intelligence sharing. In addition, the link between decision-makers and scientists should be maintained by regular events like the SCI-232 Symposium. Until now, the RF DEW focus has been on protection, but there is a need to develop RF DEW capabilities and hence a need for inclusion of these aspects in the follow-on activities.

NATO leadership, military and researchers were provided with a wide description of past and present activities within the NATO science and technology community. The Symposium added to the corporate knowledge base of NATO. It was a significant, but not a final step, in ensuring that NATO is aware of the progress of this technology.

Figure 20: SCI-227 Test Site.

PROVIDING KNOWLEDGE, ANALYSIS AND ADVICE TO SUPPORT DECISION-MAKING AND POLICY DEVELOPMENT

Risk-Based Planning (SAS-093)

The objective of the SAS-093 Task Group is to develop a risk-based framework for the strategic or long-term defence planning of NATO, providing a format for individual NATO countries to integrate with. Risk-based planning may allow Nations to take into account the variations (both negative and positive) from an expected outcome in future plans. In general, it supports value creation by enabling (especially) the highest level managers (but in actuality all levels) to deal effectively with potential future events, and to respond to them.

Risk-based planning should enable risk-informed management decisions regarding the mission, key objectives and the reputation of an organisation. It should also integrate risks from across functional areas to indicate the degree of uncertainty associated with key departmental objectives. Risk-based planning should be something that everyone is involved in, not just the 'risk factory'. It should be process 'light', helping management to focus attention on key issues.

Thus, risk-based planning should be a key enabler to decision-making, be integrated across domains at all levels of an organisation, and must become integral part of doing business. SAS-093's efforts will allow Member Nations to share methodology in a systematic and formal manner, and enable Nations to develop a joint framework for the integration of risk-based planning into its processes.

SAS-093 achieved a major milestone in October 2011, holding a Planning Conference supported by several guest speakers and presentations on risk-based and risk-informed issues – the conference proceedings have been published on the RTO website.

Additionally, the Task Group agreed to publish a NATO report on currently used risk-based planning methods which will be a collection of conference presentations and additional contributions. An outline will be prepared and discussed with the Task Group members, with the report expected to be produced by the end of 2012.

Impact of Rare Earth Metal Scarcity on Deployment of Next-Generation Electric Motive Power Systems (AVT-ST-002)

The NATO RTO's RTB commissioned a Specialist Team (ST-002), under the charter of the Applied Vehicle Technology (AVT) Panel, to research the production and utilisation of rare earth elements and to assess the potential impact a scarcity of these materials may have on the deployment of NATO's next-generation weapon electromotive power systems. ST-002 includes members from the Canada, France, Germany, the Netherlands, the United Kingdom and the United States.

This team conducted a scan of the rare earth-related political, commercial and technical environments and assessed the potential impact a reduced supply of these materials would have on NATO capabilities. ST-002 also suggested a few courses of action and presented their work to the RTB, the AVT Panel, the Mechanical Systems and Materials Technical Committee and the Propulsion and Power Systems Technical Committee.

Rare earth materials have become a vital component to many applications and for many industries. The continued electrification and miniaturisation of every-day and high performance products are enabled by rare earth materials. Like it or not, our modern society has become dependent on rare earth materials and this dependency will most certainly continue to grow stronger.

Both the automobile industry and the clean energy industry will drive our dependency on these elemental materials. Wind energy has many positive attributes and is being expanded across the China, Europe and the United States, and with expectations of reducing dependency on foreign energy sources and reducing the environmental impact of power production. A state-of-the-art wind turbine design requires approximately 100 kg of rare earth magnets for every Mega Watt (MW) of generated power.

All-electric and hybrid electric cars also feed our dependency on rare earth materials. As an example, a typical hybrid electric vehicle requires approximately 15 kg of rare earth materials, principally in the energy storage components and the drive motors. Auto manufacturers around the world are expected to increase production of these vehicles, thereby strengthening our current dependency and competing with defence system applications.

Currently, 97% of the world's rare earth elements are provided by China. NATO countries and the rest of the world depend on China! Based on recent trends regarding Chinese rare earth exports and based on evolving priorities within China, ST-002 predicts China will cease to export rare earth materials and actually become a net importer of these materials within the next few years. The United States

Geological Society estimates that China contains only 60% of the rare earth materials distributed around the planet. Hence, the rest of the world does have some options including rare earth oxide mines in the Australia, Canada and the United States, and perhaps a few other recently discovered sources. But even with alternate sources of the elements, the supply chain required to convert these materials into NATO capabilities is virtually non-existent outside of China and remains as a principal issue for future NATO weapon systems.

The modern world's dependence on a few oil-producing Nations is well documented and understood by many national leaders and the typical petroleum-fuelled automobile owner. Crude oil recovery is the only step in the supply chain entirely controlled by these Nations. All other steps after recovery: petroleum refining, fluid catalytic cracking, gasoline production, distribution to filling stations and consumer access, are controlled within the automobile consumer's country. The hybrid-electric vehicle supply chain, in contrast, depends almost entirely on one Nation: China. From mining to magnets to vehicle sub-system, China dominates the hybrid-electric vehicle supply chain and modern military weapon systems have similar dependencies.

By controlling this supply chain, China can create more jobs for its growing work force. By providing various incentives and reducing rare earth exports, the Chinese government has encouraged foreign companies to relocate to China; thereby, providing more jobs and a higher standard of living for its growing population. In addition to job growth and an improving economy, Chinese leaders have recognised for decades the political leverage enabled by their rare earth natural resource. In 2010 rare earth exports were thought to have played a significant role in negotiations between China and Japan regarding a territorial dispute.

Rare earth materials may be used in various ways and in various configurations, but there are no substitutes for these elements. Rare earth elements are used in nearly every modern weapon system on land, in the air, in the sea and in space. Rare earth materials are necessary to make the world's strongest permanent magnets, the Nd2Fe14B magnet. Rare earth elements also enable high-temperature permanent magnets, such as Sm2Co17. Rare earth materials are used in batteries and fuel cells for high-energy density applications and where silent watch capability is needed. Intelligence, surveillance, reconnaissance and communication systems also depend on rare earth materials to make them small, light-weight and powerful. Rare earth materials are an essential constituent of high-performance battery and fuel cell systems and are also a critical element needed for catalytic cracking of fuels. Turbine engines used for propulsion and also for power generation use rare earth elements in thermal barrier coatings enabling higher operating temperatures. These higher temperatures translate into longer life and higher efficiency and therefore less fuel burned. Without rare earth permanent magnets, motor, generators and actuation systems would increase in size and weight by about 3X. This increased size would preclude some applications and possibly diminish warfighting capabilities. The prices of many rare earth materials have increased significantly over recent months and years, highlighting market stability risks in addition to the overall scarcity concerns.

Potential courses of action for NATO could include strategic stockpiling, recycling and political action. A more comprehensive understanding of the current quantities and specific weapon system applications of rare earth elements would help to reduce supply risk and also contribute to assessing the potential benefit of recycling. Other courses of action include accelerating existing mine projects, expanding rare earth exploration, and incentivising the commercial world to rebuild within NATO countries more segments of the various supply chains. ST-002 recommends as a long-term course of action that NATO countries collaborate and focus research efforts in order to develop rare earth-lean or even rare earth-free alternatives to current materials and components.

As a result of the work of ST-002, NATO RTO has established an Exploratory Team to refine this assessment, continue to disseminate this message, and to further investigate some of these potential courses of action.

Figure 21: Some of ST-002 Members at Molycorp's Rare Earth Mine in Mountain Pass (USA).

Measurement of Effectiveness of Psychological Operations as Part of Information Operations (HFM-160/HFM-183)

The emphasis of military operations is shifting more and more towards non-kinetic activities, such as Psychological Operations and Information Operations (PSYOPS), which are geared towards influencing attitudes and behaviours of specific target audiences. Though many such activities are undertaken, there is little systematic evaluation of the effects they bring about and their effectiveness. As a result, it is not well known what these operations contribute to the overall operation and to what degree they achieve their goals. The purpose of the HFM-160/HFM-183 Task Group was to develop a systematic approach to the Measurement Of Effectiveness (MOE) of influence operations.

In its approach, HFM-160 considers MOE to be a process rather than a 'thing'; there is no definitive list of MOE or even an overview of best practices. All MOE are custom made for a specific situation. This approach is a way of thinking about how to assess the effects of what has been done and how effective it has been. MOE is most intuitively suited to influence operations, such as PSYOPS; however, any operation will affect attitudes and behaviours – especially kinetic operations. For this reason, this approach generalises across the whole operations spectrum: from PSYOPS and Civil Military Co-operation (CIMIC) to the most assertive kinetic activity. This Task Group has used the NATO PSYOPS doctrine (AJP 3.10.1) as a starting point and has augmented it specifically for MOE.

Though it is not possible to become an expert overnight, the Task Group's approach to MOE provides an understanding of the complexity of attitudinal and behavioural MOE, the basics of how to embed MOE in operations, and the basics of how to develop MOE such that it yields the desired – or at least useful – information. This approach is for operational and tactical levels working with, commissioning, developing or interpreting MOE for any type of influence activity.

The most important key concepts in this approach to MOE are 'effects' and 'effectiveness'. Effects refer to changes in the environment, potentially brought about by actions, though other forces may also lead to observed effects. Effectiveness refers to the degree to which actions are responsible for bringing about the desired effects. With effects, what causes them is relatively unimportant as long as the effects are manifested. In terms of effectiveness, how the change comes about is key. It is not enough that change has occurred – if you want to evaluate effectiveness, you must gain insight into the cause of a change: either your actions or something else.

Our approach contains seven steps:

1) Define the effects you want to achieve;
2) Define impact indicators for each effect, which are measurable concepts that indicate attitudinal and behavioural change;
3) Define thresholds, which identify the level of change necessary to conclude that you have been successful;
4) Specify data collection methods;
5) Specify data analysis techniques;
6) Specify activities to undertake in order to achieve the desired effects (interventions); and
7) Define separately indicators of effectiveness, to help determine the degree to which your actions led to changes in the impact indicators.

In order to help end users understand these seven steps, we have developed a Technical Course (HFM-183), which instructs trainees on the main points of the approach.

INFORMING MILITARY FORCE GENERATION AND EMPLOYMENT

Mental Health and Well-Being Across the Military Spectrum (HFM-205)

Combat places a tremendous psychological and physical burden on those involved. The operational deployments NATO Forces are conducting are often characterised by high levels of stress for the soldiers. Significant numbers of them develop mental health problems afterwards. These problems include Post-Traumatic Stress Disorder (PTSD), alcohol-misuse, violence and aggression and risk-taking behaviours, to name but a few. No Nation's forces are without impact.

The HFM-205 Symposium provided a timely and successful venue to set a framework for future HFM work on mental health and well-being within the Military. The Programme Committee selected four keynotes and 41 papers that covered a wide range of topics pertinent to the Symposium's theme.

The mental health problem issue clearly has two faces: prevention and treatment. In the course of the Symposium, evidence emerged that the relationship between exposure to one or more traumatic events and the development of PTSD is not simply one of cause and effect. Many factors (e.g., personality, leadership quality, unit-cohesion, duration of deployment, length of deployment) intervene in the process of developing PTSD and other mental health issues. These parameters offer the opportunity for further preventive action. Mental health training in particular is a very important tool for the prevention of mental health problems, yet additional actions to create a military-wide favourable environment are urgently needed.

In the domain of mental health treatment, it was noticed that while help is available, many veterans in need do not seek help or drop out of therapy early. Among the reasons for not seeking help – stigma (i.e. the fear of negative consequences of admitting having a problem such as rejection by peers or jeopardised career prospects) and negative perceptions (e.g., "I don't trust mental health professionals") are seen as the most prominent barriers. Changing attitudes is key to increasing the probability that veterans in need will seek help. Implementing the desirable attitude change within a traditionally tough (macho) military culture is a real challenge and specific research to support this endeavour is suggested.

Some emerging technologies were presented, which include virtual reality training, neuro-feedback and tele-rehabilitation. The technologies look promising, but currently lack sufficient empirical and pertinent evidence. It is recommended that well-designed research be conducted to demonstrate the usability of these technologies in real-world settings.

Enhanced CAX Architecture, Design and Methodology (MSG-105/MSG-106)

In 2007, HQ-SACT initiated a NATO Education and Training Network (NETN) project, which later became programme 'Snow Leopard', to establish a persistent, joint NETN capability at the strategic, operational and tactical levels by leveraging existing national capabilities. The RTO Task Group MSG-068, in support of NETN, developed initial technical solutions to enable distributed training and exercises. A final Stand Alone Experiment (SAE) showed the technical feasibility of a network of distributed simulations.

A demonstration during I/ITSEC 2010 elicited strong interest from numerous Nations for a reference architecture and community standards. However, the initial technical capability is insufficient to support the full vision, so MSG-068 recommended additional technical development. MSG-068 noted the lack of an established long-term process for the maintenance of the initial reference architecture and standards, nor provisions for improvement.

Finally, MSG-068 was unable to more closely link or assess its capabilities against the operational support requirements. A new group under the umbrella of the NATO Modelling and Simulation Group is going to be launched to complete the former MSG-068.

The objectives for this new RTO Task Group are to:

1) Update the MSG-068 reference federation architecture and Federation Object Model (FOM) design document to improve and extend it based on tested technical solutions.
2) Provide guidelines for EXCON and SIMCON (Exercise Control and Simulation Control) in performing Computer-Assisted Exercises (CAX).
3) Support the MSG-106 products for:
   - Recommendations for the governance and maintenance of products;
   - Standardisation, dissemination, quality assurance and risk management; and
   - Co-ordination and collaboration with external bodies.

Interoperability between simulations is of major importance for NATO and the Nations. As long as the demonstration of its efficiency is not done, forces will not use it for its computer-assisted exercises. The objectives of this project are to prove the technical feasibility of this interoperability and the operational implementation. Both objectives are strongly linked when in most cases, exercise controllers and simulation controllers work separately with a lack of co-ordination.

The ultimate goal of this project is to provide the Armed Forces with the tools to train in distributed configuration so that the training will be more efficient and less expensive. The Task Group is scheduled to finish in 2015.

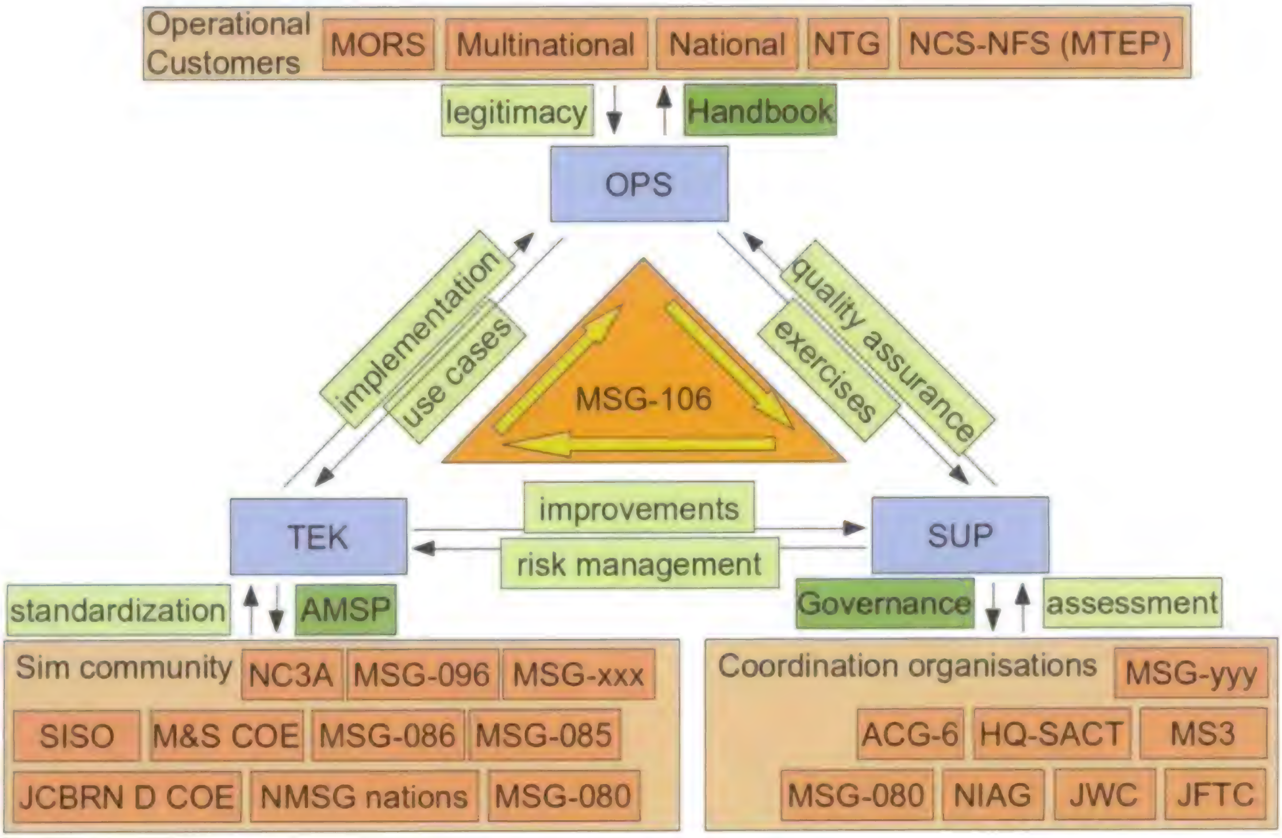

Figure 22: The Scope of MSG-106 Task Group.

Mild Traumatic Brain Injury in a Military Operational Setting (HFM-193)

Mild Traumatic Brain Injury (mTBI) resulting from exposure to blast has garnered increased attention as a cause of morbidity in soldiers serving in Afghanistan and Iraq. There remain significant gaps in our knowledge about the epidemiology, diagnosis, assessment, natural history and relationship to comorbid problems such as PTSD and optimal management. Because this problem potentially impacts all NATO Partners serving in theatres of operation where there is high risk of exposure to blast, there is great value in having an international forum for sharing information, research collaboration and establishing best practices for the management of this injury.

Those who have sustained an mTBI in theatre will experience a transient and reversible impairment in consciousness and executive function that potentially makes them a risk to themselves and others until they have fully recovered. The primary goals of in-theatre management are to exclude more severe injuries and to assess fitness for duty. Management strategies that have been adopted by some NATO Partners are largely modelled on clinical guidelines developed in the sports literature which are evidence-based, and where the evidence is lacking, rely on expert opinion. However, their use in the military context has not been rigorously evaluated.

Figure 23: Mild Traumatic Brain Injury (mTBI) is Difficult to Diagnose.

In the post-deployment period, those who experience a multitude of symptoms many months following the occurrence of deployment-related mTBI present a complex clinical picture. Soldiers who have returned from deployment to a combat zone frequently experience ill health from a

variety of causes, many of which are not well understood. There is abundant data which shows that an important minority of soldiers returning from combat experience psychological illnesses such as PTSD, depression and substance abuse. Others experience a variety of medically unexplained physical symptoms – an observation that initially emanated from Gulf War I, but is now largely recognised to have existed even before that particular conflict. The diagnostic dilemma is further compounded by the fact that post-concussive symptoms are common in the general population and are non-specific. Not surprisingly, this complex picture has spurred differences in opinion on how best to manage those with late or persistent symptoms following a history of exposure to blasts.

As a consequence of these concerns, HFM-193 was created in 2009, mentored by the United States and chaired by Canada, with the goal of achieving the following objectives:

1) To describe current clinical practice for all participating NATO Nations;
2) To provide a summary of current research projects and predicted target dates for completion;
3) To identify existing gaps in knowledge; and
4) To elucidate principles for best practices.

Other NATO members participating in this group include France, Germany, the Netherlands, Sweden and the United Kingdom.

The Task Group has met three times and is creating a technical report. Topics to be covered will include a description of existing clinical practice from all participating NATO Nations; a summary of current research projects and predicted target dates for completion; the identification of existing gaps in knowledge; and principles for best practices.

Figure 24: Primary and Secondary Effects of Blasts Can Cause mTBI.

SUPPORTING CAPABILITY DEVELOPMENT PROCESSES

3D Modelling for Urban Terrain (SET-118)

Better modelling of the geometric and physical properties of 3D urban terrain presents an opportunity to enhance the generation of the NATO's Common Relevant Operational Picture (CROP) for its militaries. Such modelling will support visualisation of the operational environment, which in turn will enhance a user's situational awareness, especially in complex urban scenarios like those depicted in Fig. 25.

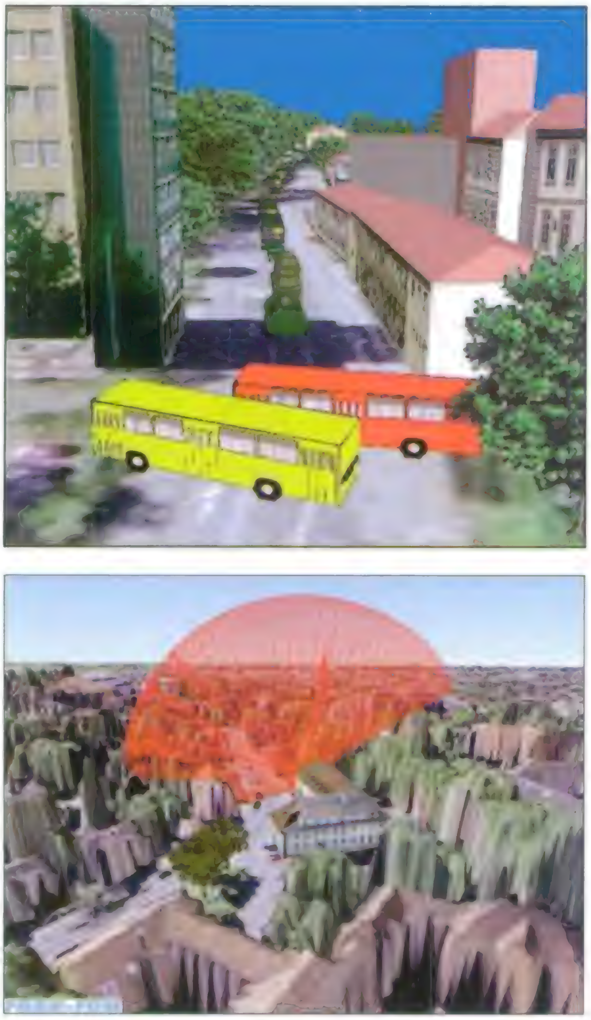

Figure 25: Exemplar Urban Scenes for Mission Planning and Threat Analyses of Military Applications Requiring 3D Models.

Of equal and increasing significance are inputs to non-visualisation tasks like mission planning, line-of-sight determination, change detection, assessing the capability of a sensor network, threat analysis, and calculating acoustic, chemical and electromagnetic propagation. The concepts and requirements for military applications strongly suggest the need for capabilities to process large data sets in a timely manner, to update and augment existing models, and to provide multi-scale representations of operational environments.

The SET-118 Task Group (2008 – 2010) was formed to study various representations of objects in urban environments, to evaluate procedures for automatically reconstructing scenes by exploiting the data from modern sensors, and to discuss current and potential metrics and criteria for assessing those procedures. The technologies that were investigated cover active and passive sensors, such as flash lasers, video and Interferometric Synthetic Aperture Radar (InSAR). During its three-year activity, the Task Group compiled and pooled data sets for benchmarking and investigations on different data sources. Workflows were established by applying state-of-the-art algorithms, e.g., starting with pre-processing by waveform analysis, reconstructing surfaces by assimilating sensed points and interpreting scenes by classification.

Figs. 26 and 27 depict automatic model-based scene reconstructions of buildings from airborne Light Detection And Ranging (LIDAR) data and InSAR images, respectively.

Last but not least, the Task Group collected, developed and studied various metrics and evaluation criteria for the specification of the accuracy of scene representation. Metrics based on human goals were developed for potential quantitative assessment in the future.

The need for more accurate, up-to-date and comprehensive 3D models of urban terrain is likely to increase significantly in the near-term and mid-term, which drives the desires for standardisation and more research and development in this area.

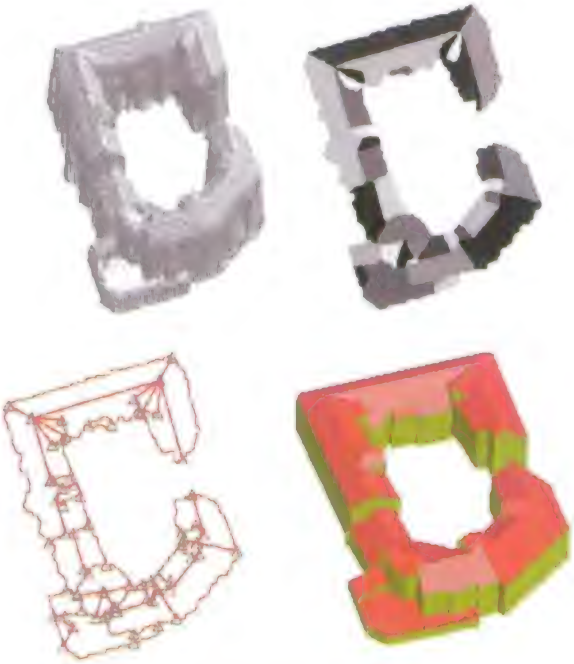

Figure 26: Automatic Model Instantiation from Airborne LIDAR Data of 3-Dimensional Building.

Figure 27: Model-Driven Automatic Building Reconstruction from Interferometric SAR Images.

Non-Lethal Weapons Capabilities-Based Assessment (SAS-078)

The North Atlantic Council identified Non-Lethal Weapons (NLW) as a "critical, additional capability needed in order to meet the demands of future operations". On-going operations have repeatedly confirmed this need.

In Afghanistan, laser dazzlers and acoustic hailing devices are used to warn approaching vehicles, reducing undesired engagements. Rapidly deployable nets are used to deny access or stop vehicles, enhancing force and facility protection. Flash-bang grenades and stun devices are used in building and room entry to degrade or disable threats and increase the time available to resolve dangerous situations.

As the first ever alliance-wide Capabilities-Based Assessment (CBA) of non-lethal weapons, SAS-078 successfully completed a very ambitious agenda and conducted ground-breaking work. SAS-078 accomplished:

1) **Requirements analysis**, across 37 ACT/SAS-078-developed scenarios, resulting in detailed Counter-Personnel and Counter-Materiel NLW requirements (which received Bi-Strategic Command endorsement in a letter signed 16 February 2010 by General Karl-Heinz Lather, Chief of Staff SHAPE and Vice Admiral Robert Cooling, Chief of Staff ACT), marking the first time NATO has had formally recognised NLW requirements.
2) **Capabilities analysis**, with data on current, programmed (funding allocated/available by 2012), and potential (on-going research and development/ potential availability by 2020) non-lethal weapons.
3) **Gap analysis**, which compared current and programmed NLW versus requirements to identify the degree of requirement accomplishment, characterise capability gaps and prioritise gaps.
4) **Solution analysis**, identifying and assessing materiel and non-materiel solutions and the degree to which identified gaps can be resolved, as well as characterising remaining gaps.
5) **Experimentation**, formulating an integrated NLW experimentation framework to provide a common basis for sharing results, developing experimentation protocols and carrying these out in field and laboratory experiments (Fig. 28 shows a counter-personnel case from the Runners Exposed to Acoustics and Light / Drivers Exposed to Acoustics and Light (REAL DEAL) experiments conducted at Camp Rena, Norway), and writing the first issue of a NLW Experimentation Guidebook.
6) **Co-ordination** with other NATO NLW activities, especially the Defence Against Terrorism (DAT)

initiative on Non-Lethal Capabilities (DAT-11). DAT-11 supported SAS-078's REAL DEAL experiments, and SAS-078 provided extensive support for DAT-11's October 2011 North American Technology Demonstration (the largest NLW event held to date, with more than 100 NLW vendors and more than 1,000 visitors, including senior officials from NATO and Member Nations).

The extensive work of SAS-078 is documented in a final report and 20 annexes. As a consequence of SAS-078, NATO and its Member Nations have a clear and detailed characterisation of:

- What the Alliance's non-lethal weapons requirements are, as well as the linkage between these requirements and a wide range of operations;
- Where current/programmed capabilities can make a difference and which are most versatile, highest scoring, or uniquely applicable to a requirement;
- Where current/programmed NLW fall short and R&D is needed; and
- Where candidate materiel solutions could make a difference and which offer the greatest potential in terms of being most versatile, highest scoring, or uniquely applicable to a requirement.

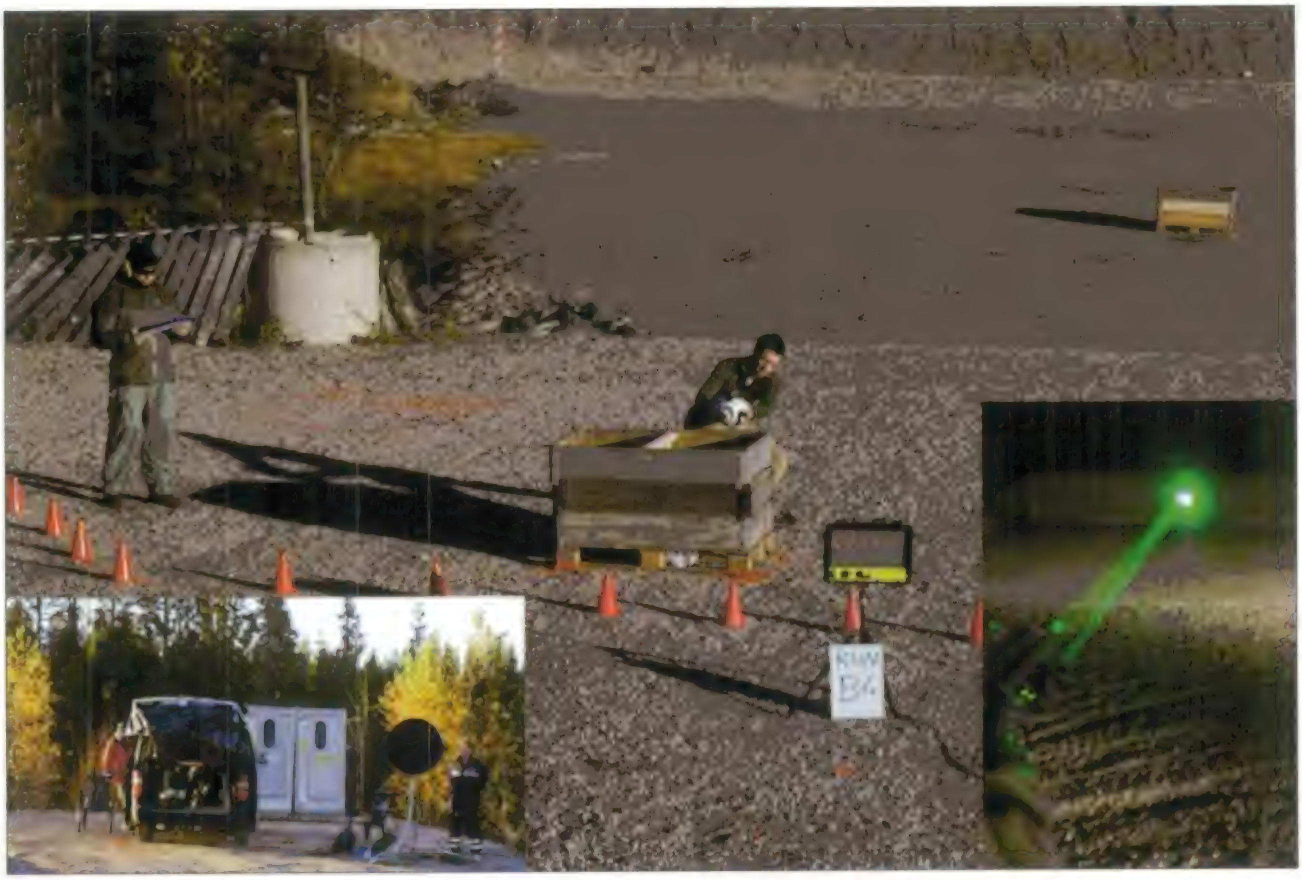

Figure 28: Counter-Personnel Experiment (Credit: Norwegian Defence Research Establishment (FFI)).

CONTRIBUTING TO CONFIDENCE BUILDING AND THREAT MITIGATION TO ADDRESS IMPORTANT SECURITY NEEDS

Information Assurance and Cyber Defence (IST-091)

All information technology systems, whether military or civilian, are subject to non-static threats. The impact on some control systems (e.g. power stations) could be catastrophic if sustained attacks are successful. Hackers are becoming more sophisticated. Botnets are becoming more prolific. Transfer of cyber information and knowledge needs are improving, both in quality and timeliness, which requires trusted communications. The vocabulary of the discipline needs to be consistent for all the users (use of ontology).

On 22-23 November 2010, the Information Systems and Technology (IST) Panel organised a Symposium on "Information Assurance and Cyber Defence" in Tallinn (EST) that brought together many experts from NATO Nations, Partnership for Peace Nations (Austria, Finland, the Russian Federation, Sweden and the Ukraine) and Mediterranean Dialogue Nations (Algeria and Morocco).

A welcome speech by the Estonian Minister of Defence, Dr. Jank Aaviksoo, emphasised the importance of the topics addressed at this Symposium, particularly when he coupled the disciplines with those discussed at the NATO summit in Lisbon. Many aspects of cyber defence were approached during the Symposium including:

- Prospects for deterrence and arms control in cyberspace;
- Intrusion detection prediction and counter-measures;
- Security models and architectures;
- Security policies evaluation authorisation and access control; and
- Network and information security awareness.

This event addressed a wide number of issues within cyberspace and provided a forum to disseminate information in an informal manner. At the same time it was recognised that some of these topics might be sensitive, but dissemination of information was critical to cyber defence (which was not restricted to the military). It was also recognised that the need to liaise with Coalition Partners to share information of an attack had become widespread.

Moreover, the timely transfer of information, particularly across national boundaries, was advocated throughout the Symposium. It was also acknowledged that the transfer of information was a cultural aspect and in some instances better protection would be afforded when the legal and political constraints were removed.

Research topics were aired which progressed the knowledge in the cyber defence field and discussion led to the conclusion that further work was necessary to pre-empt the next generation of threats. Attackers are becoming more sophisticated, aided by advances in technology and the proliferation of simple devices which can propagate bugs.

Further key technological developments that could impact cyber area in the next decade were highlighted, such as:

- Cyber defence selected challenges and solutions;
- Awareness;
- Immune systems;
- Human problem;
- Timely decision-making; and
- Policies on optimising information sharing.

The dynamic nature of the potential threats demands a proactive stance to ensure that appropriate counters are available.

Figure 29: Estonian Minister of Defence Dr. Jank Aaviksoo Opening the Symposium.

Security in Collective Mission Simulation (MSG-080)

NATO ACT is developing plans for the implementation of a Distributed Training and Exercise (DTE) capability. The technical blueprint for the architecture and infrastructure to support the DTE vision has been developed and tested by MSG-068 NATO Education and Training Network (NETN). Effective, yet flexible ways of dealing with the related security issues have to be developed, tested and accredited for DTE to fully realise its potential. MSG-080 is the first step in this direction.

In addition to Coalition training applications, the approaches investigated by MSG-080 should also contribute to addressing security issues that are encountered in national military and civilian-military training events. Examples are the Swedish Viking XX exercises or the Dutch, German and American Joint Air and Missile defence JPOW exercise series. The British Department of Transportation and Communications (Air) project (formerly Mission Training through Distributed Simulation) also sees interoperability as

being a critical enabler for a cross-domain UK defence training capability. Whilst the project focuses primarily on the air domain, it is looking to develop a security solution which would work across all domains to achieve truly effective joint collective training.

Collective mission simulation is proving an important enabler to achieve military objectives within application areas such as training, analysis and concept development. However in many cases, the simulation models need to exist within different security domains and must be protected, while at the same time information needs to be shared. Security concerns may be even more prominent in cases where civilian organisations and simulations are also involved in a peace-keeping or peace-enforcement types of exercise (e.g., police forces, NGOs or other support services).

Therefore an increasing need has been identified for solutions that enable the sharing of simulation information across different classified security domains to establish collective simulations without the potential for undesired information leakage and confidentiality breaches.

The RTO Task Group MSG-080 has been established to focus on how information within different security domains can be protected with a minimal impact on the operation of the collective mission simulation. Furthermore, the activity will focus on how to share information in a secure, effective and efficient way that does not require extensive modifications per simulation, as is sometimes the case today.

Potential solutions may include information release using role-based policies and/or labelling and release mechanisms. These solutions should be closely bound to the simulator or (national) simulation domain that they protect. The solutions need to be an integral part of the simulation development and accreditation process.

The intention of this Task Group is to:

- Establish a common understanding of the terminology associated with M&S security issues.
- Investigate the problem space by identifying and examining use-cases from the national and NATO domain.
- Investigate possible solutions and their applicability for specific aspects of the problem space – this may include some experimentation.
- Investigate policies and procedures for security as part of the M&S development process.
- Investigate policies and procedures for the accreditation processes.
- Provide recommendations to NMSG for information security methods and processes that better meet current and future needs.

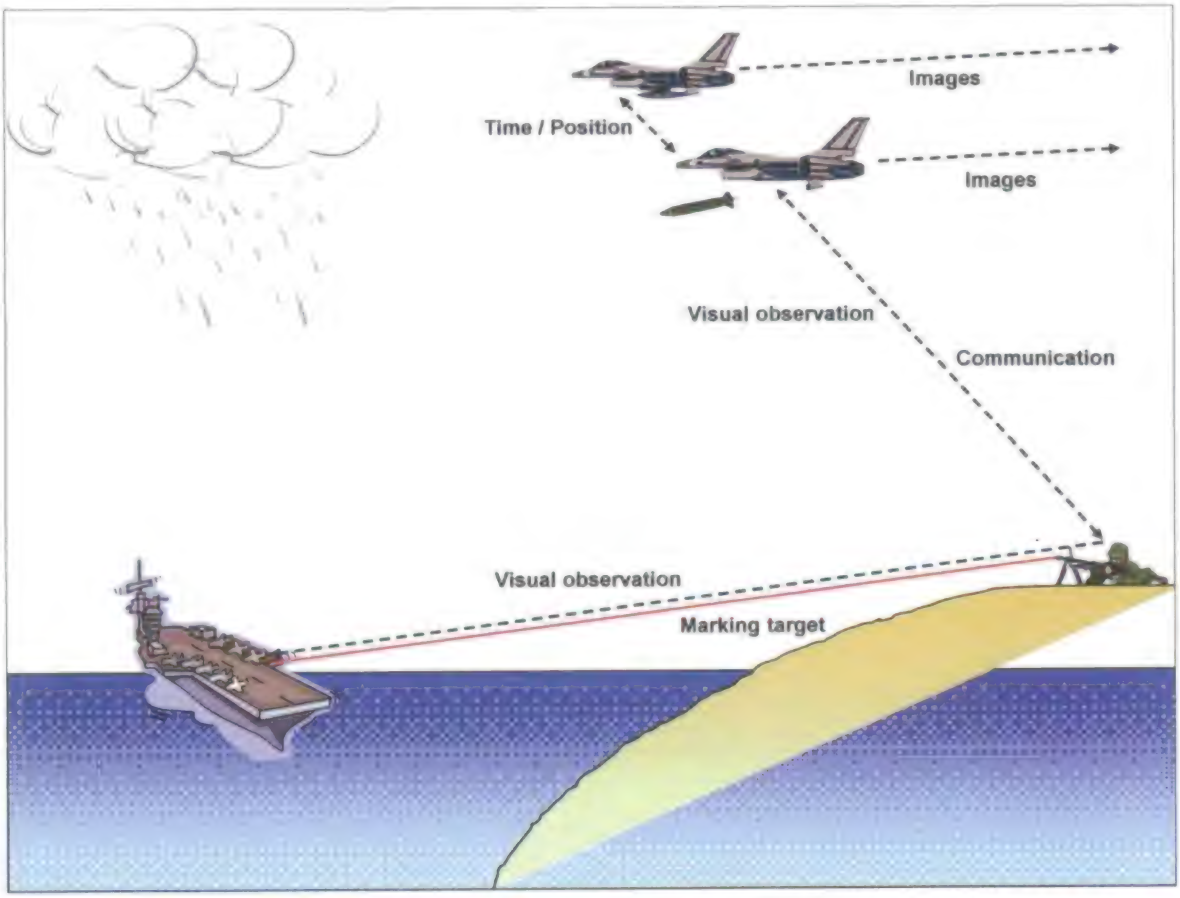

Figure 30: An Example of Collective Mission Simulation.

NATO RTO Panels and Group – Advancing Technical Excellence

In addition to the collective response to warfighter needs addressed in the holistic approach described in the previous section, the RTO organises its work along technical domains assumed by the six Panels and the NATO Modelling and Simulation Group. This section offers a review of their mission, scope of work and selected highlights from 2011.

THE APPLIED VEHICLE TECHNOLOGY PANEL (AVT)

The AVT Mission

The Applied Vehicle Technology Panel strives to improve the performance, affordability and safety of vehicles through advancement of appropriate technologies. The Panel addresses vehicle platforms, propulsion and power systems operating in all environments (land, sea, air and space), for both aging as well as future vehicle systems.

The Scope of the AVT Panel

In fulfilling this mission, the Panel is focused on three technology areas:

- Mechanical systems, structures and materials;
- Performance, stability and control, fluid physics; and
- Propulsion and power systems.

The Panel carefully reviews proposed future activities to ensure the coherence and balance as well as the relevance of its programme. In this process, specific emphasis is placed on NATO's long-term requirements and on-going programmes such as DAT. This way, the members of this strong community of researchers are constantly aware of NATO's current and future needs when they provide their contributions to NATO's capabilities.

The trend of addressing subject areas common to all theatres of military operations as well as application-oriented technology has thus been successfully adopted. It encompasses an intense consideration of NATO's needs and works in close co-operation with the ACT and all relevant elements of the structure under the CNAD.

AVT Programme of Work

To accomplish this mission, AVT members exploit their joint expertise in:

- Mechanical systems, structures and materials;
- Propulsion and power systems; and
- Performance, stability and control and fluid physics.

The technical activities AVT performs within and across these three disciplines may be grouped into two broad technology areas:

1) **Vehicle and Platform Technologies**, including: vehicle and platform design – computational fluid dynamics and fluid mechanics – stability and control – noise and vibration control – structural loads and dynamics – smart structures – structural materials and manufacturing processes – affordability, availability, survivability and supportability – reliability, maintenance and repair – environmental impact – testing.
2) **Propulsion and Power Technologies**, including: air-breathing engine design (piston, gas turbine, ramjet/scramjet) – rocket motors and rocket-based combined cycles – electric propulsion including hybrid systems – engine control and thrust vectoring – power generation and storage – fuels and combustion – power-plant materials and structures – propellants and explosives – operation, health monitoring, reliability, maintenance and affordability – environmental impact – testing.

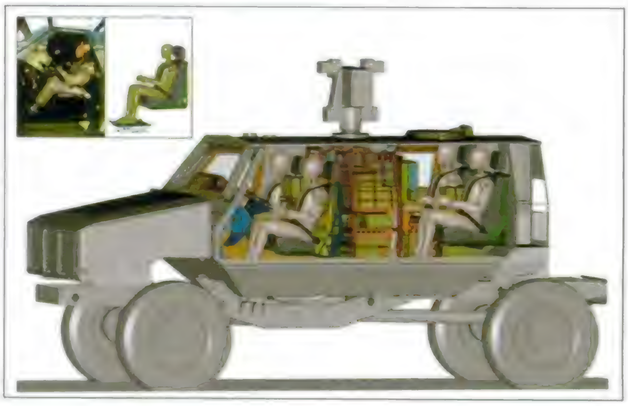

Figure 31: Modelling and Simulation in the Development of Mine Protected Vehicles.

The challenges NATO faces today require innovative technologies in vehicle design in order to achieve larger

payload, wider range, higher speed, improved deployability and increased versatility, to name only a few. The AVT Panel is dedicated to investigating and providing suitable technologies, such as:

- Health management/monitoring of propulsion systems;
- Compact high-power density prime movers, energy generation and storage;
- Drag reduction for sea and air vehicles;
- Morphing aircraft;
- Design for disposal of munitions;
- Self-healing materials, damage repair in the field; and
- Lightweight armour for both vehicles and personnel.

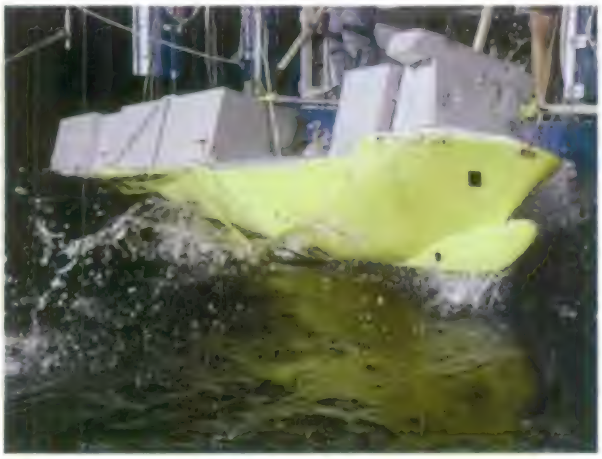

Figure 32: Experimental Measurements for Course Keeping in Wave.

A substantial amount of research is done on nanotechnology for applications in military vehicles (such as stronger/stiffer materials, coatings) and power systems for military applications (reduced fuel-consumption, lightweight and man-portable alternative sources such as fuel cells). Presently, the most visible application of a large number of these new technologies is unmanned vehicles for air, sea and land (covering all aspects of their aerodynamic and structural design, control and power supply, including Micro-unmanned Aerial Vehicles (MAVs)), and the design and application of greener munition technology.

In conjunction with the AVT Panel Business Weeks in 2011, one Workshop, two Specialists' Meetings and one Symposium took place covering the following topics:

- "Virtual Prototyping of Affordable Military Vehicles Using Advanced Multi-Disciplinary Optimisation (MDO)";
- "Active Suspension Technologies for Military Vehicles and Platforms";
- "Assessment of Stability and Control Prediction Methods for NATO Air and Sea Vehicles"; and
- "Munition and Propellant Disposal and its Impact on the Environment".

Selected AVT Highlights

Materials and Processes for Battle Damage Repair on Land and Naval Vehicles (AVT-155)

Repair of damaged military platforms or their components is of considerable concern for all NATO Nations as it affects readiness, economic and safety issues – and given the reduction of military budgets across NATO, there is a definite need for new and more effective repair procedures. Additionally, the use of new materials means that maintenance techniques need to be reviewed in order to improve repair capabilities.

The aim of the AVT-155 Task Group is to share common Battle Damage Repair (BDR) tools and testing activities on land vehicles and naval assets, with a potential for application on aeronautical systems. Its objectives are to:

1) Identify key system elements for managing battle damage phenomena on composite or heterogeneous ballistic panels;
2) Set up a Round Robin Test (RRT) between participating Nations to quantify damage assessment and propose repair procedures; and
3) Share engineering qualification test plans and procedures on repair.

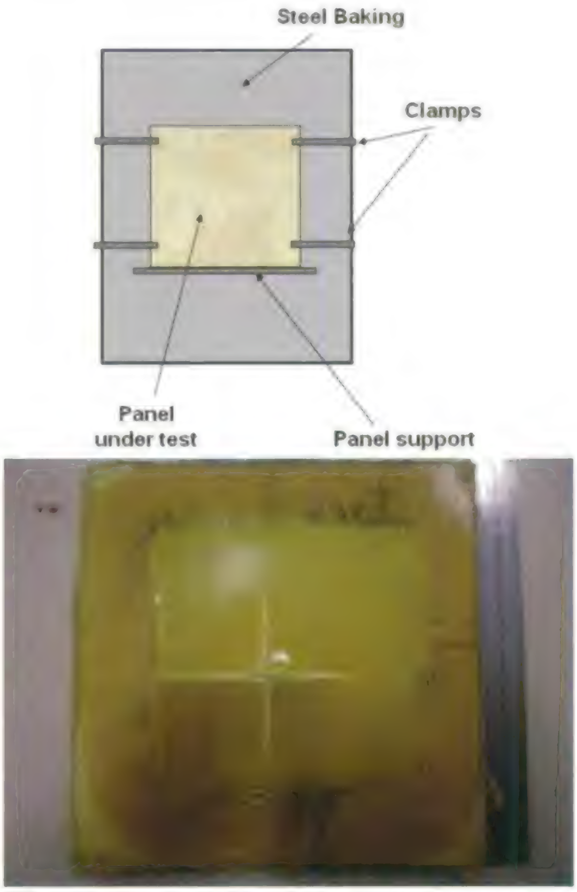

Figure 33: Ballistic Test Configuration – Panel Repairing – Ballistic Damage After Repairing.

In order to manage the battle damage on the ballistic composite panels, non-destructive technologies have been used to assess damage size and to evaluate repairing techniques.

AVT-155 has identified two different approaches to repair:

1) A 'fast' methodology; and
2) A 'massive' methodology.

According to STANAG 4569, the first produced acceptable ballistic results for both Kevlar and Kevlar/ceramic panels, but introduced large modifications to the initial structure in terms of weight/shape.

The second approach produced good results for Kevlar panels but not very good ballistic results for Kevlar/ceramic panels. In fact, test results demonstrated that for this type of panel, the 'massive' repairing approach is only effective in certain boundary conditions.

The Task Group demonstrated that ballistic armour can be repaired, identifying a potential equipment list that will allow damage assessment/repair to be performed 'on site'. This represents a significant improvement in the design approach for new armoured fighting vehicles, which is the first step towards using repairable ballistic materials in a vehicle's primary structure.

Symposium on "Munition and Propellant Disposal and its Impact on the Environment" (AVT-177)

The NATO RTO Symposium on "Munition and Propellant Disposal and its Impact on the Environment" was held in Edinburgh (GBR) during the AVT Fall Panel Business week from the 16-20 October 2011. The mission of the Symposium was to build on the output from the AVT-115 Task Group and other NATO studies by further sharing and developing knowledge and expertise in the area of munitions demilitarisation and environmental management. The aim was to provide an updated and developed capability for NATO and PfP Nations, as well as increased user awareness of the area.

The scope of the Symposium was to support the military capabilities on "Through Life Management of Munitions" and the "Defence Against Terrorism". The technical focus was to identify critical environmental security issues for disposal of explosives, pyrotechnics, initiators, missile and gun propellants, and to make recommendations on future disposal policy in a secure manner, removing them from possible terrorist use.

Over 80 participants from 14 Nations including Georgia and Russia attended the Symposium. During the four days, 36 papers were presented within the sessions, giving an overview on the topic, dealing with policy issues, the industrial demilitarisation capabilities, the management of munition contaminated sites, and the way ahead to greener munitions. The Symposium concluded with a roundtable discussion during which several topics were raised, such as capability gaps, the type of research required in the future, the main problems facing NATO, the effect of legislation (taking into account the differences between NATO members), and questions concerning recycling and qualification issues.

The technical evaluator, Mr. Lee Meyer from the USA, gave a very interesting wrap up of the Symposium to the AVT Panel. He summarised the most important contents and outcome of the four sessions. Finally, Mr. Meyer summarised the overall outcome and stated that the topic is very serious and important for further work. All of the Member Nations that participated have contaminated ranges that require clean up. All Member Nations have some form of remediation and/or requirements for the clean up of contaminated areas.

Specialists' Meeting on "Assessment of Stability and Control Prediction Methods for NATO Air and Sea Vehicles" (AVT-189)

The NATO RTO Specialists' Meeting on "Assessment of Stability and Control Prediction Methods for NATO Air and Sea Vehicles" was held at Dstl in Portsdown West (GBR) from 12-14 October 2011. The goal of the Specialists' Meeting was to disseminate the findings of the RTO Task Group AVT-161, to discuss them with a wider audience, and to review the work of others who were not part of the Task Group and to evaluate new ideas and a way forward for the follow on activities (AVT-201 (air facet) and AVT-216 (sea facet, proposed)).

The meeting was held over three days, with two sessions per day. Within the four 'air activity' and two 'sea activity' sessions, 30 papers were given on the subjects of: applicability and use of computational fluid dynamics methods for prediction of vehicle aerodynamics and motions for air and sea vehicles, comparison of predictions with well-documented experimental test cases, the ability to model vehicle stability and control characteristics for typical configurations, and requirements for improving prediction methods for the future.

The approximately 80 participants saw a very interesting composition of presentations from academia and industry including keynote speakers who opened each session.

The two technical evaluators, Dr. Atlee Cunningham from Lockheed Martin for the 'air activity' sessions and Dr. Joseph Gorski for the 'sea activity' sessions, gave a very valuable closing report on the contents of the meeting.

Dr. Cunningham summarised that there are impressive new experimental facilities available to assess highly accurate dynamic wind tunnel data for computer code validations. Nevertheless, dynamic testing is more or less only possible in low-speed facilities and the range of manoeuvrability is limited as well. On the other hand, significant progress was made regarding computational methods, which could fill the gap in the future for the entire flight envelope as replacement for portions of the flight test programme. He also reminded

the participants that there is a significant potential for Reduced Order Modelling (ROM) methods.

Dr. Gorski summarised the meeting with his perspective regarding computational methods for sea vehicles. He believes that the shallow water manoeuvring problem is being well predicted by computational simulations. However, for seakeeping in waves, Computational Fluid Dynamics Reynolds Average Navier-Stokes (CFD/RANS) still has difficulties and is not necessarily easy to implement. In his opinion, it is even more difficult to implement all the details one would want (propellers, moving rudders, associated controllers, etc.), as well as taking all possible boundary conditions into account (such as all possible wave forms). He remarked that the capability exists to obtain reasonably accurate predictions, but there still appears to be trust/confidence issues in the results.

All in all, the AVT-189 Specialists' Meeting was a very successful and helpful event, especially for summarising and closing a Task Group activity that made great progress at finding the right way forward. The results of the meeting were addressed to the Panel during the AVT Panel Business Meeting (PBM) the following week in Edinburgh (GBR).

THE HUMAN FACTORS AND MEDICINE PANEL (HFM)

The HFM Mission

The mission of the Human Factors and Medicine Panel is to provide the science and technology base for optimising health, human protection, well being and performance of the human in operational environments with consideration of affordability. This involves understanding and ensuring physical, physiological, psychological and cognitive compatibility among military personnel, technological systems, missions and environments. This is accomplished by the exchange of information, collaborative experiments and shared field trials.

The Scope of the HFM Panel

The scope of the HFM Panel is multi-disciplinary and encompasses a wide range of theory, data, models, knowledge and practice pertaining to Health, Medicine and Protection (HMP), Human Effectiveness (HE) and Human System Integration (HSI). These three domains are complementary and represent the three 'Area' committees of the HFM Panel:

1) The **Health, Medicine and Protection Area** provides the scientific basis for establishing an operationally fit and healthy force, restoring health, minimising disease and injury, optimising human protection, sustainability and survivability. This encompasses research in the field of military medicine, physiology, psychology and human protection technology. Areas of interest include, among others, medical diagnosis, prevention, treatment and evacuation. HMP also focuses on enhancing human protection research on physiological and physical influences, e.g., of cold, heat, air pressure, noise, motion, vibration, ionising and non-ionising radiation, chemical and biological effects on the human body, acceleration, and developing appropriate counter-measures.
2) The **Human Effectiveness Area** optimises individual readiness and organisational effectiveness by addressing psycho-social, organisational, cultural and cognitive aspects in military action. Contributions on individual readiness cover values and ethics, leadership, multi-national operations and coping with new demands on the individual. Contributions on organisational effectiveness encompass human resource management, training, interoperability, shared decision-making, synchronised situational awareness, understanding terrorism, psychological operations and coping with new demands on military organisations.
3) The **Human System Integration Area** optimises the performance of human-operated technical systems by addressing the human-machine interactions, processes, tools and measures of effectiveness. Specific contributions cover complexity, total life-cycle affordability, human error and fatigue management, intelligent agent, human-system communication, human cognitive and physical resources management, anthropometry, interface, design of information displays and controls, human-human communications and teamwork, performance enhancement and aiding, training and function allocation in automated systems.

HFM Programme of Work

The HFM Panel portfolio of research is predominantly focused on human performance enhancement, organisational effectiveness, medical preparation and after-care for missions and the integration of human factors.

In 2011, the Panel continued to conduct research in the areas of advancements in distributed learning, training technologies, medical technologies, mental health and human modelling.

Co-operation within NATO and with Partners

The Human Factors and Medicine Panel fosters co-operative research in behavioural sciences and medicine among NATO Nations. The HFM Panel reaches these goals by setting up co-operative demonstrations of technology and shared experiments, based upon international co-operation between, for instance, the ACT and the NATO Committee of the Chiefs of Military Medical Services (COMEDS) on behavioural sciences and medicine. Ex-officio members of ACT and COMEDS join the Panel Business Meetings of the HFM Panel.

Within NATO, the Public Health, Food and Water Group (PHFW), the former Joint Medical Committee (JMC), advises the Senior Civil Emergency Planning Committee (SCEPC) on civil matters affecting NATO. PHFW also acts as the co-ordinating body for the SCEPC regarding all medical policies, procedures and techniques.

In an endeavour to be more open in their Programme of Work (PoW), the HFM Panel has made their Symposia available to participants PfP Nations, MD, Global Partners (GP) and selected Contact Countries.

The Specialists' Meeting and Symposium planned for 2012 are HFM-201 on "Social Media: Risks and Opportunities in Military Applications", to be held in Tallinn (EST) in the Spring, and HFM-223 on ""Biological Effects of Ionising Radiation Exposure and Counter-Measures: Current Status and Future Perspectives", to be held in Ljubljana (SVN) in the Fall.

Selected HFM Highlights

A Survey of Blast Injury Across the Full Landscape of Military Science (HFM-207)

Blast injury is a significant cause of casualty in current NATO operations. The term 'blast injury' creates considerable confusion in military medicine. Simply stated, 'blast injury' includes the entire spectrum of injuries that can result from exposure to an explosion. The spectrum of blast injuries and their consequences is broad. To address the research issues posed by the wide spectrum of battle injuries will require a multi-disciplinary approach. The HFM-207 Symposium focused on the key aspects of multi-disciplinary science and medicine that would provide the necessary foundation to increase our understanding of blast injury. Six Symposium sessions addressed the Programme Committee's four key themes:

1) Defining the problem;
2) Studying blast injury mechanisms;
3) Studying blast-induced head injury; and
4) Mitigating blast injury.

The Symposium provided a venue that successfully set a framework for future NATO research and technology work. In addition, it provided an initial compendium of research progress that can be used as a reference source for other NATO organisations such as the CNAD and COMEDS.

The Symposium's Programme Committee initially set three goals for this technical activity:

1) Increase the understanding of blast injury in military operations;
2) Explore and describe the range of blast injuries seen in current NATO operations; and
3) Delineate some of the medical treatment strategies currently being employed by NATO medical personnel.

These three goals were adequately addressed by the portfolio of technical presentations offered and the discussions that ensued. A fourth goal was imbedded in the selection of papers for the Symposium and in its title – engaging a multi-disciplinary scientific dialog via a 'survey' of current research. This last goal was clearly met both by the diversity of science presented and the active cross-disciplinary discussions that emerged.

Over the course of this Symposium, several significant realisations were had:

- Blast injury will require a disciplined research approach, which one reviewer termed as "the toxicology of blast".
- The need for a dialogue on the physics-based modelling of primary blast injury for existing blast scenarios.
- Research on, and the establishment of, animal models of injury will be key in the development of a medical sciences database for injury treatment.
- The pressing need for better scientific understanding of non-penetrating blast injuries to the brain, which are manifested in a host of symptoms whose aetiology is vague at best.
- The extensive bibliographies included in the technical papers presented at this Symposium provide valuable insight into the history and technical challenges posed by blast injury and as such can serve as an excellent resource tool.

Factors Affecting Attraction, Recruitment and Retention of NATO Military Medical Professionals (HFM-213)

For several years, available medical capabilities have been identified as being insufficient to meet NATO's level of ambition. Multi-national medical support, aeromedevac and deployable medical facilities were identified as medical shortfall areas. Efforts and plans are in progress to mitigate these shortfalls, and Nations are encouraged to implement the proposed steps. A key factor in the delivery of such capabilities is the availability of suitably qualified medical personnel.

At the informal Defence Ministers meeting in February 2010, the issue of recruitment and retention of specialised medical personnel was addressed and identified as a pressing concern for several Nations. Compounding this is the fact that military medical services often find themselves in competition with their national civilian health systems for qualified medical personnel. For this reason, the attractiveness of serving as a medical officer or Non-Commissioned Officers (NCO) will play an important role in determining how best to meet NATO's requirement for an adequate medical capability.

Several topics to be covered by HFM-213 are:

- Environmental factors (e.g., demography, situation in the civilian health market).
- Attraction factors of serving (e.g., public image, political support).
- Recruitment advantages and disadvantages (e.g., health care versus bureaucracy, payment, education, adventure).
- Retention advantages and disadvantages (e.g., safe employment, pension versus deployment, limited career).
- Applicable tools to compete for qualified medical personnel.

COMEDS asked the HFM Panel to collect, compile and assess the Nations' specific efforts to attract, recruit and retain (specialised) medical personnel under the general framework of demographic change and the increasing competition with the civilian health market in order to create a 'best-practice-based' toolbox with targeted measures to mitigate these critical shortfalls in the medical arena. The Task Group aims to achieve this by conducting a scientific assessment of contributing Nations' situation reports.

THE INFORMATION SYSTEMS AND TECHNOLOGY PANEL (IST)

The IST Mission

The mission of the Information Systems Technology Panel is to implement, on behalf of the Research and Technology Board, the RTO Mission with respect to Information Systems Technology; namely, to advance and exchange techniques and technologies to provide timely, affordable, dependable, secure and relevant information to warfighters, planners and strategists, and to advance and exchange techniques and enabling technologies for modelling, simulation and training.

The Scope of the IST Panel

The Information System and Technology Panel activities cover four main themes:

1) **Architecture and Enabling Technologies:**
   - Software engineering technologies;
   - Computing technologies;
   - Requirements capture;
   - Modelling and simulation technologies and standards;
   - Speech and natural language processing;
   - Groupware and collaboration tools; and
   - Robotics.
2) **Communications and Networks:**
   - Network management;
   - Network security;
   - Mobile and tactical communications;
   - Satellite communications; and
   - Frequency management.
3) **Information and Knowledge Management:**
   - Decision support architecture;
   - Data mining;
   - Data warehousing;
   - Information fusion;
   - Information filtering;
   - Visualisation;
   - Knowledge-based systems; and
   - Artificial intelligence.
4) **Information Warfare and Information Assurance:**
   - Information Security (InfoSec);
   - Computer Security (CompuSec);
   - Communications Security (ComSec);
   - Cyber war and cyber defence;
   - IP security;
   - System assurance;
   - Cross-domain;
   - Information Assurance (IA); and
   - Wireless security.

IST Programme of Work

The IST Panel portfolio of research is predominantly focused on how to advance and exchange techniques and enabling technologies to improve C3I Systems, with a special focus on interoperability and cyber security. In 2011, the Panel continued to conduct research in the areas of C4ISR, interoperability, information fusion and cyber defence.

Selected IST Highlights

C4ISR and Complex Situations: The Quest for Reliability (IST-100)

Modern C4ISR systems exemplify the powerful trend towards the exploitation of distributed Systems-of-Systems (SoS). It is widely acknowledged that integrating multiple platforms and systems in a cohesive shared environment greatly enhances capabilities. In particular, it facilitates the timely access of information across all users. But SoSs are highly heterogeneous, in their physical components as well as in their multiple forms of interactions. These may include real-time data, procedures, policies, human intelligence, i.e. a diversity of linked events/processes/entities that operate over a wide range of time scales, from instantaneous to long term.

This dense web of interactions leads to a distinctive characteristic: behaviours are not simply derivable from those of the parts, but rather arise from dynamic interactions within their ensemble and entail emerging properties – some desirable / some undesirable. Such is the realm of C4ISR resources needed for today's NATO operations involving rogue states, humanitarian missions and terrorism in the homeland.

Figure 34: Exploitation of a Distributed SoS.

The key issue that IST-100 aims at addressing is to try and find the minimum level of complexity to be introduced so as to have agility (being capable of adapting to different situations/conditions (short time) and of tracking the evolution of technology (longer term)) and resiliency (exhibiting graceful degradation when under stress or while adapting to new constraints and avoiding sudden catastrophic modes). To do so, the Task Group will develop and document an understanding of the complexity issues that confront C4ISR systems, as well as identifying and fostering sound practices, meta-design rules, methods and checklists in the main phases of the life cycle of C4ISR.

Cognitive Radio in NATO (IST-104)

Communication systems in the theatre are demanding more and more bandwidth resources. Thus, finding frequencies for Coalition deployment of forces is proving to be much more difficult, especially when factoring in mobility.

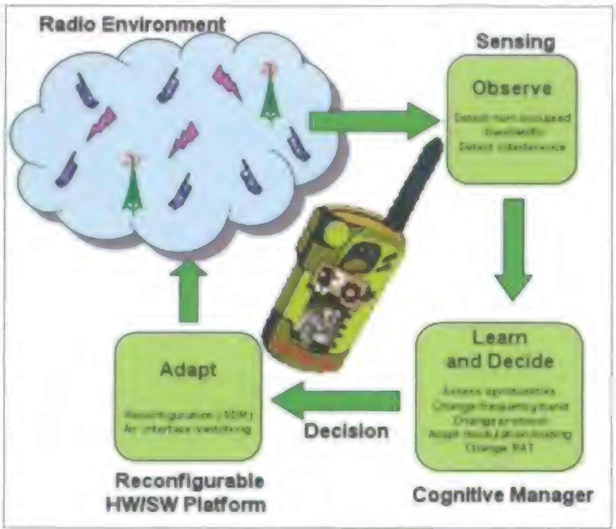

Figure 35: Cognitive Radio Concept.

Thanks to the growing flexible capabilities of communications equipment, the concept of Cognitive Radio (CR), a radio that can adapt according to its surrounding environment, is no longer a 'dream' but a reality – one that is very likely to be deployed in the near term (at least basic functions such as frequency switching). This capability will be a great help in accommodating the dynamicity of operational deployments and is expected to provide a better reuse of the frequency resource among several Nations through the co-existence of networks.

Capitalising on its predecessor's experience researching this topic, the IST-104 Task Group aims at studying the 'baby' and the first steps in implementing CR-like features in NATO communication systems, such as:

- Information sharing;
- Policies (needed between Nations);
- Impact on spectrum management; and
- Evaluation of the impacts of such techniques on NATO mission success (in terms of benefits, vulnerability and security).

Information Filtering and Multi-Source Information Fusion (IST-106)

Information superiority is one of the primary requirements for military dominance. The exploitation of all relevant information from various sources is a key factor for NATO's information superiority. To achieve the premises for NATO Network-Enabled Capability (NNEC) means to establish a common information space where all participating elements and organisations have the opportunity to supply and retrieve information according to their particular roles. This requires both powerful means for discovering and filtering and smart means for analysing and exploiting information.

Military and non-military units taking part in complex endeavours embody a large number of different positions. In a network-enabled mode of operation, people populating these positions, co-ordinate and collaborate in Communities of Interest (COIs) made-up throughout the whole endeavour. Consequently, information exchange patterns are unpredictable and complex. Producers and consumers of information are often loosely coupled, or not coupled at all. Relevant information can also be obtained from external sources such as the public media or the Internet. A lot of the information exchanged or accessed is unstructured, partly because the information is unstructured by nature, and partly due to the fact that information exchange or metadata standards are lacking (or not adhered to by some of the partners in the endeavour).

Relevant information and especially threats must be discovered in a mass of sources (mails, messages, reports, data bases, media, etc.), processed, organised, visualised, memorised and provided to the appropriate functionaries in order to achieve a superior grade of information representation that can be used as a basis for the decision-making process. These are tasks a human carries out best, but due to the enormous quantity of information that is distributed from various sources, the human capacity is over-charged and unable to react timely – hence computerised decision support tools that help to relieve experts are badly needed.

The IST-106 Task Group plans to cover a variety of topics, such as how to synchronise and align heterogeneous and possibly differing information of various sources, and how to design knowledge-based means in order to pursue the three-stage process of collecting, exploiting and storing the data.

THE NATO MODELLING AND SIMULATION GROUP (NMSG)

The NMSG Mission

The mission of the NATO Modelling and Simulation Group is to promote co-operation among Alliance bodies, NATO Member and Partner Nations to maximise the efficiency with which Modelling and Simulation (M&S) is used. Primary mission areas include M&S standardisation, education and associated science and technology. The activities of the Group are governed by a Strategy and Business Plan derived from the NATO M&S Master Plan. The Group provides M&S expertise in support of the tasks and projects within the RTO and from other NATO bodies.

The Scope of the NMSG

M&S is today a limitless revolutionary technology providing powerful tools which assist the search for improved operational effectiveness and yield value for money within NATO. Their ability to represent and examine the behaviour of equipment and the military capability of Armed Forces continues to increase, particularly with the advent of simulations carried out over a distributed network that can include humans and live (real) equipment. M&S contributes to saving lives, saving time and money, and preparing the warfighter better, faster and cheaper.

The role of the NMSG is to function as a management body in which a balanced, full range of M&S interests can be represented, and to promote the coherent management and co-ordination of M&S across all Alliance activities in the principal application areas of defence planning, technology development and armaments acquisition. The scope of activity under the NMSG is:

- M&S Policy Management – promoting exchange between the Member Nations and Alliance organisations on M&S standards and best practice, which will co-ordinate and harness individual M&S capabilities and activities for the long-term systematic benefit of NATO; this exchange must be responsive to varied interests and respond to NATO roles and missions.
- Management and Co-ordination of M&S Activities – developing, maintaining and integrating a co-ordinated, long-term strategy for NATO M&S activities; identifying and co-ordinating opportunities for M&S activities across the whole of the Alliance, including the NATO Military Authorities, the International Staff, technology development organisations and application development organisations; developing M&S project work-plans and associated resource requirements for forwarding to NATO budget authorities via the RTB; in co-ordination with the Director of the RTA, overseeing the expenditure of resources by the Modelling and Simulation Co-ordination Office (MSCO) during the execution of M&S projects.

NMSG Programme of Work

The NMSG PoW is divided into 'Common Service' programmes addressing training, standardisation and education, under the lead of members of the MSCO and Technical Activity programmes managed by Task Groups.

As part of its mission to fulfil the objectives established in the NATO M&S Master Plan, the MSCO is working in conjunction with the RTA's Information Management Systems Branch (IMSB) to provide the community with common services for development, use and re-use of M&S by means of a NATO Simulation Resource Library (NSRL).

NMSG continues to develop its relationship with the NATO ACT assisting in the development of M&S-based Advanced Distributed Learning (ADL) courses and supporting major projects such as the NETN.

From its inception in 1998, the NMSG has been keen to involve the Partner Nations in its programme of work. Currently, most NMSG activities are open for Partner participation.

Selected NMSG Highlights

Simulation - C2 Interoperation - Transatlantic Live Demonstration at the I/ITSEC 2011 (MSG-085)

As previously mentioned, the NMSG efforts include a wide range of activities supporting major NATO initiatives. One example is the effort to attain interoperability between C2 and simulation systems with the aim to achieve a 'train as you fight' environment in support of NATO operations.

Through the use of standardised Coalition battle management language (effort undertaken by MSG-048 and MSG-085 Task Groups) simulated systems will be able to exchange orders and reports with real C2 systems in distributed exercises.

During I/ITSEC 2011, in Orlando, FL (USA), the MSG-085 Task Group performed a trans-Atlantic live demonstration with C2 and simulation systems connected on both sides of the ocean.

Three training vignettes were demonstrated in separate sessions: air reconnaissance, combined operations with logistics and ground manoeuvre.

The successful demonstration showed the progress of the technical activity and demonstrated the feasibility of this ground-breaking NATO initiative.

C2-simulation interoperation provides benefits to the following key military areas of interest:

- Force readiness;
- Support for operations; and
- Future capabilities development.

The expected benefits include:

- Enhanced realism and overall effectiveness;
- Decreased cost and workload;
- Reduced preparation times; and
- Increased responsiveness.

The MSG-085 Task Group will be conducting distributed experimentation events throughout 2012, in preparation for the group's participation in a large-scale distributed training exercise similar to "Viking 2011". During this exercise, the operational relevance and usefulness of the C2-simulation interoperability technology and lessons learned will be demonstrated.

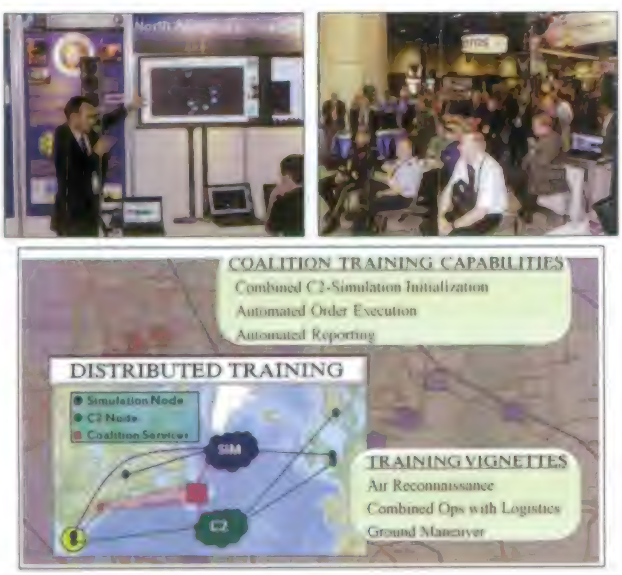

Figure 36: MSG-085 Live Demonstration at I/ITSEC 2011, Orlando (USA).

Enhance or Replace: Finding the Right Live versus Synthetic Balance – The Theme of the NMSG Symposium 2011 (MSG-087)

The NATO Modelling and Simulation Group (NMSG) Symposium (MSG-087) was conducted in Bern (CHE), 13-14 October 2011. All sessions of the Symposium were unclassified, with an audience that included experts from NATO Nations, PfP Nations and Invited Nations.

Two keynote presentations were given, one at the beginning of each day, and conference contributions were presented in seven topic sessions.

The Symposium addressed the question of how to find the right balance between live and synthetic training. In other words: is there a solution to the problem of determining the best mix of the three simulation categories Live, Virtual and Constructive (LVC) for military training?

Traditionally, live simulation involves practicing real manoeuvres and exercises, virtual simulation involves the use of simulators, such as tank and aircraft simulators, and constructive simulation involves the use of simulation systems, such as the Joint Theatre Level Simulation (JTLS) and the Joint Conflict and Tactical Simulation (JCATS). JTLS and JCATS and comparable solutions are commonly used in CAX.

The mix of these three forms increases training effectiveness and decreases costs in military training provided by NATO. In the United States, a recently released report evaluates the future of LVC enabling architectures that support the mix of all three categories. Many of the technical challenges have been solved. The remaining questions are operational and administrative in nature; for instance, how do we find the right balance between live, virtual and constructive simulations to prepare the best training for soldiers?

The two-day Symposium presented a collection of papers that dealt with related questions and addressed technical, operational and administrative challenges. A group of papers identified metrics to measure costs, effectiveness and performance to find the right balance in the LVC spectrum. Another group measured the appropriateness of LVC as a means of supporting certain training objectives.

Overall, new technologies are being exploited to overcome the current shortcomings in distributed simulation and training. Furthermore, resulting challenges that need to be addressed by administration were identified.

In summary, this Symposium gave an excellent overview of how much the NATO M&S Community has evolved in recent years and what new trends are starting to emerge regarding the successful use of all categories of LVC components. All presenting Nations and organisations are clearly in a stage of mature M&S application and apply sound engineering principles including the sharing of solutions based on open standards and open architectures.

New technologies are being evaluated and integrated to improve solutions. Other communities are engaged in solving problems on a broader and more stable foundation.

THE SYSTEMS ANALYSIS AND STUDIES PANEL (SAS)

The SAS Mission

The mission of the System Analysis and Studies Panel is to conduct studies and analyses of an operational and technological nature, and to promote the exchange and development of methods and tools for Operational Analysis (OA) as applied to defence problems.

The Scope of the SAS Panel

The System Analysis and Studies Panel portfolio of research is predominantly focussed on exploring how operational capability can be enhanced through the exploitation of new technologies, new forms of organisation, or new concepts of operations.

SAS Programme of Work

In 2011, the Panel continued to conduct research in its areas of strength, including support to operations and capability development, long-term defence planning, methodological improvements, as well as command and control theoretical development coupled with practical guidance. The Panel's 2011 PoW marked a re-emphasis on bringing the Nations' Operational Analysis / Operational Research (OA/OR) expertise to bear on current operational issues facing NATO.

Selected SAS Highlights

Long-Range Forecasting for the Future Security Environment (SAS-088)

> *"No matter how clearly one thinks, it is impossible to anticipate precisely the character of future conflict. The key is to not be so far off the mark that it becomes impossible to quickly adjust once that character is revealed."*
>
> *-- Professor Sir Michael Howard*

Previous SAS Panel Task Groups and Specialists' Meetings have worked to define inputs required at the initial step of the long-term planning process; however, these previous efforts have not prescribed specifically how to develop these inputs. Therefore, the focus of SAS-088 Specialists' Meeting was to understand the methods and approaches available to generate (and then validate) long-range forecasts, thus providing policy makers with better information to influence decisions.

The SAS-088 meeting was conducted in Stockholm (SWE), 11-12 April 2011, and was organised into three unique sessions, focusing on Methodology, Process and Integration into Policy. Each session contained a keynote address, a presentation of papers, a discussion period and a syndicate session addressing a specific topic raised in the session.

With three keynote speakers – covering policy, industry and the military perspective – along with over 40 participants from 16 NATO Nations/organisations – the meeting determined methods to strengthen linkage between foresight and policy formulation to improve the utility of foresight within the decision-making process. Other successful conclusions from SAS-088 were that:

- The national perspective is reflected both in the methods used and in the priorities given to particular attributes of the future.
- The use of a range of techniques and methods is preferred; using multiple methods will strengthen the results of foresight exercises in the eyes of decision-makers.
- Many NATO Nations lack a sufficient body of foresight experts with expertise in the appropriate methods and tools.
- Foresight studies have limited impact within many NATO Nations – Politicians are not interested as the outputs are outside the timescales of their tenure; the military appreciates the benefits, but must weigh these against short-term operational imperatives.
- The value of foresight is not in its quantitative accuracy, but rather how well it supports decision-making in the present, which requires early and continual engagement with decision-makers.

The Human Environment Analysis Reasoning Tool (HEART) – Incorporating Human and Social Sciences into NATO Operational Planning and Analysis (SAS-074)

NATO's approach to conducting operations currently, and in the foreseeable theatres of asymmetrical/non-conventional conflict, demands a comprehensive approach to achieve desired effects from the use of lethal and non-lethal means involving Armed Forces and other levers of Coalition influence. This is exemplified, for example, in present command guidance that identifies the Afghan population, rather than the Taliban, as the centre of gravity for International Security Assistance Force (ISAF) operations. Successful application of a comprehensive approach requires an evolution of military capability, in concert with an improved understanding of the human and social dimension of conflict.

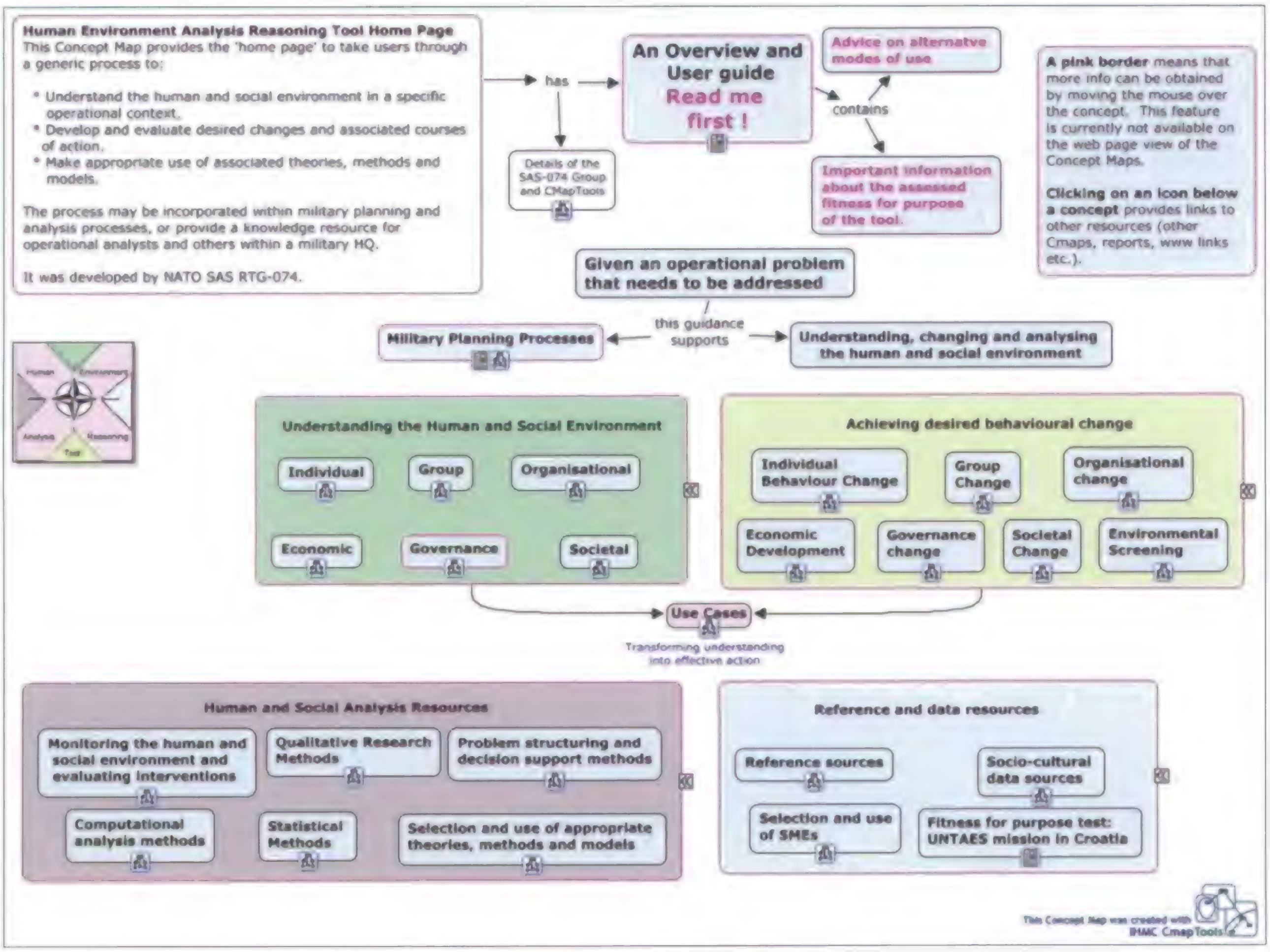

Figure 37: SAS-074 HEART Model Process View

The work of SAS-074 led to the development of a demonstration visual reasoning tool, the HEART, to help military staff and analysts understand the human and social environment, develop effective courses of action, and make use of appropriate analysis methods. It directly addresses recommendations made by five previous NATO Task Groups (MSG-024, MSG-028, SAS-027, SAS-044 and SAS-057).

HEART encourages the development of understanding the human and social aspects of the operational environment, and can be used to support early phases of military planning processes, such as the orientation and concept development phases of the NATO's Operational Planning Process (OPP), or as a more general knowledge resource.

NATO Independent Cost Estimating and the Role of Life-Cycle Cost Analysis in Managing the Defence Enterprise (SAS-076)

NATO Nations must deal with significant budget reductions, and procurement programmes are facing intense scrutiny in light of scarce resources. Nations must commit resources early in the acquisition process when significant decisions are made, even though:

- Little (if any) of a programme's total cost is known;
- Years of system development and production, and decades of operating and support costs, need to be estimated; and
- System characteristics may change during development or production.

SAS-076 sought to test best practices in cost analysis through hands-on case studies and, additionally, to explore current practices in defence capability portfolio analysis. Both efforts were intended to engender more informed resource decision-making within the Alliance, in the face of flat or falling defence budgets.

Thanks to the immense work, dedication and esprit de corps of the Task Group members, many of them luminaries in the international constellation of defence planning and cost analysis, SAS-076 climbed far beyond its lofty goals into the rarefied, thin air of major scientific breakthrough. SAS-076 reached the summit of extraordinary achievement by:

- Pushing the state-of-the-art in defence cost analysis with pioneering, award-winning work that's resonating so strongly today that estimates of cost risk for critical programmes such as Joint Strike Fighter (JSF) and Ohio Replacement Program [the next generation of fleet

ballistic missile submarines] are now adopting some of SAS-076's methodology.

- Supporting NATO's acquisition of the top-priority Alliance ground surveillance system by developing the only Independent Cost Estimate (ICE) of the programme, and the first-ever ICE conducted using a team of NATO analysts.
- Orchestrating an international conference on defence capability portfolio analysis at Ecole Militaire, Paris (FRA), with 19 presentations given in two days by leading experts from over a dozen countries. SAS-076 identified commonalities and differences in approaches, and recommended a set of best practices to guide current efforts in defence planning.

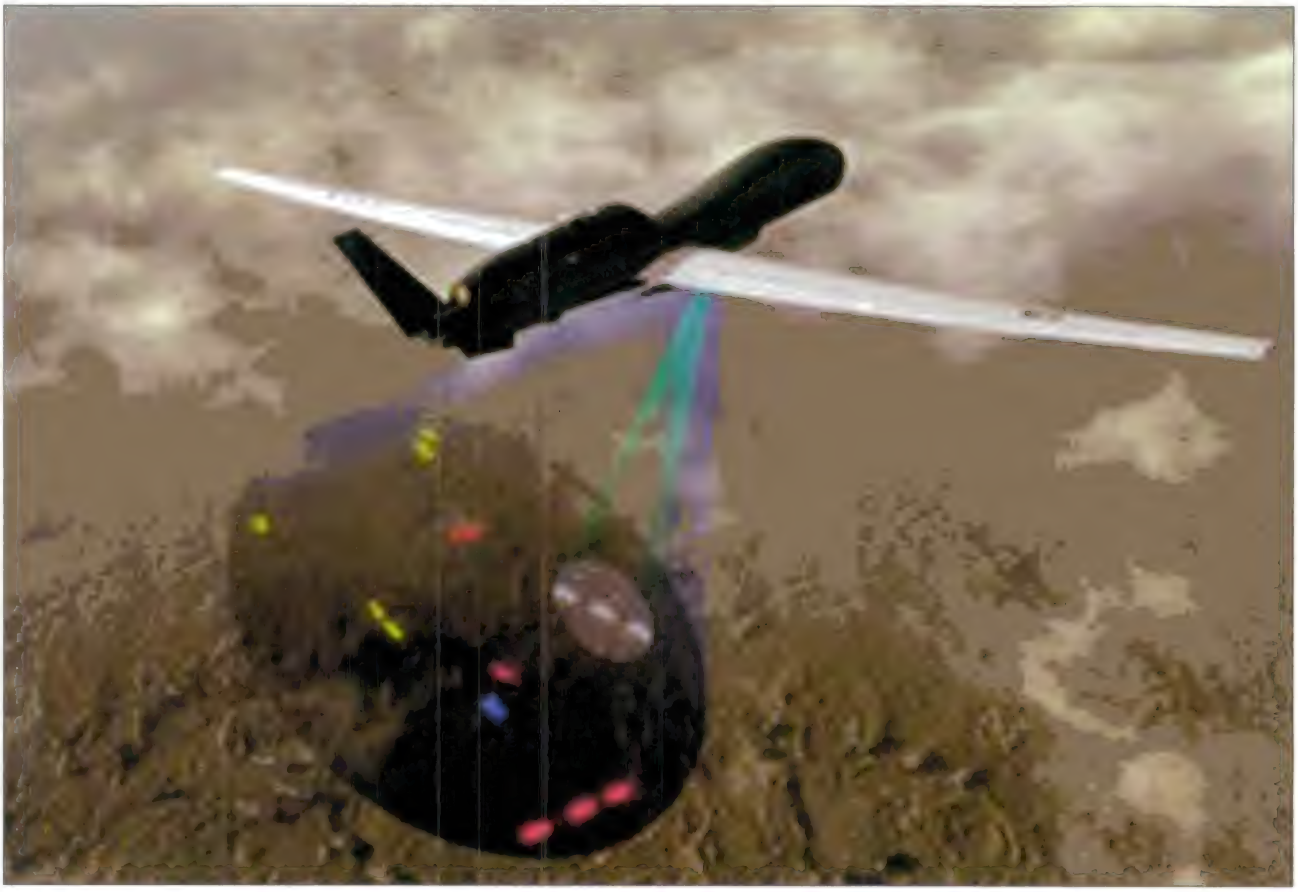

Figure 38: NATO AGS Concept.

THE SYSTEMS CONCEPTS AND INTEGRATION PANEL (SCI)

The SCI Mission

The mission of the Systems Concepts and Integration Panel is to further knowledge concerning advanced systems concepts, integration, engineering techniques and technologies across the spectrum of platforms and operating environments to assure cost effective mission-area capabilities.

The Scope of the SCI Panel

The scope of the Panel activities covers a multi-disciplinary range of theoretical concepts, design, development and evaluation methods applied to integrated defence systems, including air, land, sea and space systems (manned and unmanned); associated weapon and counter-measure integration are also covered.

SCI Programme of Work

The Panel relies on scientists, engineers, military officers and industry experts from across NATO and Partnership Nations to accomplish its mission. Task Groups and Exploratory Teams focus on a broad range of topics, including:

- Space awareness and operations;
- Flight test and unmanned aerial vehicles;
- Camouflage and force protection;
- Route clearance and counter-improvised explosive device operations;
- Directed-energy weapons; and
- Electronic warfare.

Selected SCI Highlights

Enhanced Camouflage

The SCI Panel continues to research and develop solutions to enhance the force protection of NATO forces using advanced camouflage. A series of on-going Task Groups have examined camouflage in hot, humid areas; performance criteria for camouflage systems derived from operational scenarios; and advanced materials, systems and evaluation methods for adaptive camouflage. These activities have great potential to support NATO Nations' military Commanders in current and future operations.

Infra-Red Counter-Measure Techniques Against Imaging Seekers (SCI-192)

A key aspect of SCI Panel activities involves developing counter-measures against advances systems that could be used by NATO adversaries. Infra-red and electro-optically guided weapons continue to increase in complexity, capability and diversity, and pose an increasing threat to Armed Forces operating on land, at sea and in the air.

Developments in infra-red and electro-optical technology have led to seekers with improved capability to reject conventional counter-measures. Self-protection of military units has become more and more important, especially in current military operations where politics and public opinion will ask for the best equipment and the best protection for the units involved.

Unfortunately, terrorists and insurgents have access to some of these infra-red and electro-optically guided threats. In this asymmetric warfare, the use of these weapons becomes highly unpredictable and unconventional, both in location, operation and selection of targets. One example is the use of anti-tank weapons against ships in littoral waters.

The SCI-192 Task Group set out to identify and specify counter-measures and counter-measure concepts against advanced Infra-Red/Electro-Optically (IR/EO) guided weapon threats. The Task Group developed new seeker tracking algorithms and performed laboratory experiments on optical hardware to better understand the threat technology. The resulting flare counter-measure sequences set up by SCI-192 turned out to be successful for cases where their simulation models predicted success.

The efforts of the SCI-192 Task Group have enhanced NATO capabilities and increased the safety of NATO warfighters. For their exceptional team effort and outstanding contribution, the Task Group was presented the 2011 RTO Scientific Achievement Award.

Directed Energy Weapons (DEW) Related Capabilities: Near, Mid, and Long-Term Prospects (SCI-227)

The SCI Panel sponsored a Symposium on directed-energy topics, focusing on RF DEW. RF DEW can be used to degrade the operation of equipment or cause permanent damage. As transmitter capabilities improve, NATO must consider the possibility that the newest technology could be used to defeat critical NATO systems. Interest in RF DEW is increasing and NATO decision-makers require an appreciation of both offensive and defensive capabilities and applications.

The Symposium provided a forum for out-briefing the results of the SCI-198 Working Group on the protection of military networks against high-power microwave attacks. In addition,

it was an opportunity to share the results from the SCI-227 Specialist Team on "Directed-Energy Weapons (DEW) Related Capabilities: Near-, Mid- and Long-Term Prospects". SCI-227 was established following a request by NAFAG.

The SCI-198 briefings covered the susceptibility testing of NATO tactical computer networks, identifying potential susceptibilities and ways to harden the networks. In addition, RF DEW detection techniques were discussed.

The SCI-227 presentation examined the current capabilities for developing directed-energy weapon applications and linked these capabilities to technology needs identified by NATO. Other topics were also presented, including a summary of RTO high-power RF activities, source development efforts, vehicle stopping, sensor technology, calculation of electromagnetic fields and the DE threat.

During the Symposium, several issues were also identified:

- There is an increasing vulnerability of commercial and military networks;
- An overall NATO strategy on RF DEW is lacking;
- There is a definite need for intelligence sharing; and
- The link between decision-makers and scientists appears to be weak.

The Symposium arrived at several key recommendations:

- An overall NATO strategy for DEW needs to be developed;
- Efforts are initiated to improve intelligence sharing; and
- There is a need to develop RF DEW capabilities (until now, NATO RF DEW focus has only been on protection).

NATO leadership, military and researchers were provided with a wide description of activities (both past and present) that are on-going within NATO. The Symposium added the corporate knowledge base of NATO. It was a significant but not a final step in ensuring that NATO is aware of the progress of this technology.

Figure 39: Panel Executive LTC. Jim Zink and Dr. Ernst Krogager Prepare to Brief SCI-198.

THE SENSORS AND ELECTRONICS TECHNOLOGY PANEL (SET)

The SET Mission

The mission of the Sensors and Electronics Technology Panel is to foster co-operative research, the exchange of information and the advancement of science and technology among the NATO Nations in the field of sensors and electronics for defence and security. The SET Panel addresses electronic technologies as well as passive and active sensors as they pertain to Reconnaissance, Surveillance and Target Acquisition (RSTA), Electronic Warfare (EW), communications and navigation, and the enhancement of sensor capabilities through multi-sensor integration and fusion.

The Scope of the SET Panel

The SET Panel research activities predominantly address the phenomenology related to target signature, propagation and battlespace environment, Electro-Optics (EO) / acoustic / Radio-Frequency (RF) / magnetic sensors, antennas, signal and image processing, components, sensor hardening, electromagnetic compatibility, and any other phenomena associated with sensors and electronics that assist NATO warfighters during future warfare and peace-keeping scenarios.

The SET Panel is partitioned into three Focus Groups:

- RF Technologies (RFT);
- Optical Technologies (OT); and
- Multi-Sensors and Electronics (MSE).

The main purpose of each Focus Group is to provide a convenient and efficient forum for in-depth technical discussions during the SET business weeks. The Focus Groups review updates of NATO guidance and their applicability to the SET Task Groups, Exploratory Teams and on-going activities of the Technical Team, examine and propose new activities, discuss Technology Watch topics and propose award nominations.

Technology Watches are performed by the SET Panel as part of its normal business, in order to monitor the development and emergence of new technologies and to review and analyse their potential impact on military capabilities.

The SET Panel identifies various on-going programmes on enabling technologies and initiates discussions on areas related to emerging technologies. The activities undertaken by the SET Panel embrace the following disciplines:

Phenomenology:

- Target and background signatures;
- Propagation;
- Battlespace environment characterisation;
- Sensors hardening; and
- Electronic protection measures and electromagnetic compatibility.

Sensors:

- EO sensors (ultraviolet, laser radars, imaging IR, IR search and track);
- RF sensors (radar, radiometers, gonyometers) and related technologies, including passive RF sensors;
- Acoustic, seismic, magnetic, chemical and inertial sensors;
- Urban, indoor and subterranean navigation sensors;
- THz sensors (from the point of view of military technology, especially in the context of urban warfare and DAT); and
- Dual-use sensors for a wide range of applications (urban/high-intensity to security/low-intensity).

Electronics:

- Processing:
  - Antenna processing and aperture control;
  - Signal processing;
  - Image processing;
  - Multi-sensor fusion; and
  - Pattern recognition, including automatic target recognition.
- Components:
  - EO (optics, integrated optics, fibre optics, focal plane arrays, lasers);
  - RF (antenna, amplifier, filter, Digital Radio Frequency Memories (DRFMs), Monolithic Microwave Integrated Circuits (MMICs), high-power microwave sources);
  - Micro-electronics;
  - Micro-mechanics;
  - Displays; and
  - Mechanical, chemical, etc.
- Sensor Hardening:
  - Electronic protection measures; and
  - Electromagnetic compatibility.

At present, the SET Panel is comprised of more than 50 national representatives and top-class scientists from 24 of the 28 NATO Nations. In addition, an Ex-Officio member from the NC3A participates in the Panel Business Meetings.

Traditionally, the Panel covers the whole spectrum of RTO activities (Symposia, Specialists' Meetings, Lecture Series

Workshops, Courses, Exploratory Teams, Task Groups), with a special emphasis on Task Groups. Many Task Groups are closed to allow participating Nations to work on sensitive signatures and technology. The Technical Team members are made up of more than 700 scientists from NATO and non-NATO Nations.

In 2011, the SET Panel supported more than 40 activities (32 Task Groups, 3 Exploratory Teams, 3 Lecture Series, 5 Symposia / Specialists' Meetings / Workshops). In 2012, fifteen new activities are forecasted, with the total number of activities expected to remain constant.

SET Programme of Work

SET Contribution to Military Requirements

The SET Panel Community focuses its work on S&T that is relevant to NATO military requirements. The technologies that are addressed in SET activities support all the identified DAT requirements, as well as the 38 LTCRs identified by ACT. In particular, several Task Groups are contributing to the following capabilities:

- LTCR #H2 on "Counter-IED Capability" (the SET Panel has been assigned as the 'Lead Body' for this effort);
- ISR Collection Processing, Fusion and Exploitation Capabilities (LTCR H.07-H-08);
- Assured Precision Strike Capability (LTCR L.01); and
- Counter Low Signature Airborne Targets Capability (LTCR L.02).

According to the established NATO S&T priorities, the SET Panel has created several new activities toward discovering implementable solutions and fieldable technologies that mitigate, and possibly overcome, the technical challenges currently facing NATO operations. To that end, the Panel is addressing STHPs and E2DTs in the following areas:

- Persistent EO/IR surveillance;
- Low-cost night vision;
- Fibre lasers with high average power;
- Unmanned Combat Air Vehicle (UCAV) with autonomous surveillance, reconnaissance and target recognition capabilities;
- Total situational awareness – Active Electronically Scanned Array (AESA);
- Robust, quick and ready display of information to soldiers;
- Biology-based solutions;
- Novel power sources; and
- New sensing.

In particular, the SET Panel will lead pilot activities in the following six E2DTs and STHPs:

- E2DT #5 – Sensing technologies for RF and electro-optical applications (hyper-spectral, terahertz);
- E2DT #6 – Low-cost night vision (solid-state silicon technology at room temperature);
- E2DT #18 – Stealth/counter-stealth technologies;
- STHP #1 – Minimise fratricide and collateral damage in joint fires;
- STHP #7 – Improve survivability of air assets; and
- STHP #8 – Defeat the Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) terrorist threats.

Towards the Future

The SET Panel identifies various on-going programmes on enabling technologies and initiates discussions on areas related to emerging technologies. According to the SET areas of interest, the current Technology Watch topics are:

- SAR systems (multi-static SAR, long-range high-resolution imaging of humans);
- Distributed radar (mobile distributed radar sensors – swarming, multiple RF function sensor systems);
- Advanced radar (millimetre-wave phased arrays, Multi-Input Multi-Output (MIMO) radar, emerging passive radar, noise radar, cognitive sensors, quantum radar);
- Signal and data processing (multi-function radar resource management, compressive sensing for radar, recognition of human behaviour);
- RF hardware (wideband systems, shared antenna apertures, microwave-modulated optics);
- RF technologies for EW systems (DRFM, wideband (0.5 – 44 GHz), bi-static Electronic Counter-Measures (ECM), electronic protection, electronic attack, Electronic Support Measures (ESM), Electronic Intelligence (ELINT) (intra-pulse modulation);
- Optical technologies (plasmonics for IR detectors, flexible displays, laser sources and fibre delivery; high peak power laser source; image fusion; biometric sensors; waveform diversity and analysis for laser radar, black silicon, low-cost night vision); and
- Multi-sensor and electronics technologies (quantum dot electronics and sensors, nano-wire electronics and sensors, quantum computing, quantum cryptography (teleportation of information), multi-function approach to smart textiles).

Selected SET Highlights

Impact of Wind Turbines on Radar (SET-128)

The SET-128 Task Group is concluding a study on the influence of wind turbine farms on the performance of military and civilian radar systems operating within line-of-sight of the turbines. The evidence from research and trials shows that wind farms will disrupt NATO air-defence and air-traffic-control radar systems. These problems can potentially be mitigated on some radar systems by modifying legacy radar systems, but at a significant cost – therefore new radar systems must be procured with additional requirements to ensure that the clutter effects from wind farms can be mitigated. A detailed final report is expected in 2012.

Acoustics and Autonomous Sensing for ISR Applications (SET-142)

The SET-142 Task Group recently concluded its three-year study to identify and assess emerging acoustic sensing and autonomous sensing technologies for intelligence, ISR applications and persistent surveillance to protect ground forces operating in battlefields and peace-keeping areas. In particular, the investigated technologies addressed site surveillance along borders, monitoring main supply routes and protecting base/camp sites – with concentrations on the detection, classification and localisation of:

- Indirect fire and direct fire (artillery, rocket, mortar, snipers, explosions); and
- Personnel, light ground vehicles and small airborne targets.

SET-142 performed three field experiments (Empire Challenge 2010 (USA) in July 2010; STANTA (GBR) in March 2011; Bonnland (DEU) in September 2011) and provided an aerostat sensor platform in Bonnland (DEU) (Fig. 40). As a result of their excellent results, the SET Panel endorsed the formation of a follow-on Task-Group on "Battlefield Acoustic Sensing, Multi-Modal Sensing and Networked Sensing for ISR Applications".

The concept development, engineering and management of the persistent surveillance capabilities for Counter-Insurgency/Counter-Terrorism (COIN/CT) operations, using a C4ISR system-of-systems approach, will also be the primary focus of the joint SET-183/IST-112 Symposium, which will be held in Quebec City (CAN) in the Spring of 2012. The Symposium aims to identify critical knowledge gaps and to propose a research agenda to fill those gaps.

Figure 40: Aerial Surveillance via Aerostat of Bonnland, Übungsdorf (DEU).

Multi-Sensors Integration for Urban Operations (SET-153)

Carrying on the work started in 2010, SET-153 continues to identify the sensor technologies and combinations thereof that add value at the low tactical level (platoon) in an urban environment. This Task Group conducted a field trial in Bonnland (DEU) to form the basis for recommendations on integrated sensor capabilities and limitations in urban terrain.

Signature Management System for Radar and Infra-Red Signatures of Surface Ships (SET-154)

SET-154 endeavours to obtain information and tools that are required for the (national) development of an Integrated Ship Signature Management System (ISSMS). Its focus is on radar and infra-red sensing modalities, but will also account for signature results from related SET activities – particularly those associated with SET-144 (Infra-Red Signatures) and SET-166 (Underwater Signatures).

The three groups (SET-144, SET-154, SET-166) carried out joint experiments, measurements and trials during a major campaign conducted with the Canadian research vessel Quest in September 2011 in Surendorf (DEU). Denmark, Germany, the Netherlands and the United Kingdom sent measurement radars to the trial. Germany also supplied other ships and boats. A report summarising the results is expected in the near future.

Thermal HSI Phenomenology and Exploitation (SET-ET-072)

The Nations participating in the SET-ET-072 Exploratory Team agreed on two compelling NATO requirements:

1) To make progress on the understanding of the phenomenology of Long-Wave Infra-Red (LWIR) hyper-spectral sensing and the contribution of Mid-Wave Infra-Red (MWIR) hyper-spectral sensing and Short-Wave Infra-Red (SWIR) hyper-spectral sensing to support LWIR exploitation; and
2) To develop a shared hyper-spectral dataset to make progress in understanding the performance of hyper-spectral imaging exploitation algorithms.

Consequently, the SET-ET-072 Nations unanimously recommended the creation of a Task Group whose objective would be to plan and execute a joint airborne summer trial (to be conducted in 2014) to exploit the collected data. This trial will focus specifically on the detection and identification of IED observables and on CBRNE threats in general.

The knowledge (phenomenology, data, exploitation tools) generated by this effort will contribute to understanding how to mitigate IED-related threats by focusing on the detection of specific observables during their life cycles. The SET Panel endorsed the creation of this new Task Group.

OUR FINEST – AWARDS

von Kármán Medal

The von Kármán Medal is awarded for exemplary service and significant contribution to the enhancement of progress in research and technology co-operation among the NATO Nations carried out in conjunction with RTO activities. The von Kármán Medal consists of a silver copy of the gold medal presented to Dr. von Kármán at NATO Headquarters in Paris in July 1962, on the occasion of the Tenth Anniversary of the formation of AGARD.

On 28 September 2011, during the week of the RTB meeting, held in Sofia (BUL), Dr. Ernst Krogager (DNK) was awarded the 2011 von Kármán Medal. As an internationally-recognised authority on advanced technologies in the areas of radar polarimetry, non-co-operative target recognition and high-power microwaves, for over 25 years Dr. Krogager has been a major contributor to NATO activities within AGARD, the DRG, other NATO bodies, and in particular RTO Panels on Sensors and Electronics Technology (SET) and Systems Concepts and Integration (SCI).

Figure 41: Dr. Ernst Krogager Receiving the von Kármán Medal from Dr. Walker.

Scientific Achievement Award Winners

2011 Scientific Achievement Award Winner: Unsteady Aerodynamics for Micro Air Vehicles (AVT-149)

On behalf of the AVT-149 Task Group, Prof. Funda Kurtulus accepted the RTO Scientific Achievement Award for their remarkable contribution in the field of micro air vehicle technologies. MAVs potentially provide a revolutionary capability for tomorrow's warfighter, especially in urban environments. The combination of small size and high manoeuvrability enables MAVs to operate within close proximity of targets of interest in highly cluttered environments, including indoors. The Task Group achieved a tremendous knowledge enhancement regarding the flow physics and aerodynamics of MAVs.

The results in the field of fundamental, experimental and computational research led to a better understanding of the interplay between the motion, flow-field and aerodynamic loads history, elucidation of the limits of quasi-steady aerodynamic models and identification of the remaining gaps in current state-of-the-art computational methods. These fundamental results will be used in the future design and layout of micro air vehicle applications.

Figure 42: Prof. Funda Kurtulus Receiving the Scientific Achievement Award from Dr. Walker.

2011 RTO Scientific Achievement Award Winner: Long-Term Scientific Study on Joint Operations 2030 (SAS-066)

Mr. Paul Massel and the members of the Joint Operations 2030 Task Group performed the first-ever analysis of the future operating environment, anticipated capability needs and the resultant implications for scientific research in a combined air, land and sea context.

The Task Group was able to craft a final report that provides a strong and rigorous foundation for future defence investment planning for both NATO (via the NATO Defence Planning Process) and the Nations. The efforts of the SAS-066 Task Group have enhanced the NATO capabilities planning and technology investment process.

Figure 43: Mr. Paul Massel Receiving the Scientific Achievement Award on Behalf of SAS-066.

2011 Scientific Award Winner: Infrared Countermeasure Techniques Against Imaging Sensors (SCI-192)

Dr. Ric Schleijpen and his colleagues set out to identify and specify counter-measures and counter-measure concepts against advanced IR/EO-guided weapon threats. The Task Group developed new seeker tracking algorithms and performed laboratory experiments on optical hardware to better understand the threat technology. The resulting flare counter-measure sequences set up by SCI-192 turned out to be successful for cases where their simulation models predicted success. The efforts of the SCI-192 Task Group have enhanced NATO capabilities and increased the safety of NATO warfighters.

Figure 44: Dr. Walker Presents the Scientific Achievement Award to Dr. Ric Schleijpen.

CUSTOMER SATISFACTION

The main features that make the RTO highly relevant as NATO faces the challenges of an increasingly complicated and constantly evolving world are directly connected with complex operations (e.g., in Afghanistan), increasing fiscal austerity, energy shortages, environmental concerns and rapidly emerging technologies.

The RTO provides an effective forum for the Nations to leverage their respective R&T programmes. Through this robust programme of co-operative activities, the RTO helps develop R&T capabilities in areas critical to the Nations and NATO capabilities, their tools, ideas and networks, and helps build coherence and synergy among the Nations' R&T investments and between the Nations' and NATO's needs.

The "Priorities for the RTB" document has identified Strategic Assessment, conducted periodically, as one of the RTB's critical responsibilities and a priority to be addressed. This assessment will include the definition of innovative tools that can be used in order to further measure RTO customer satisfaction. With the involvement of key stakeholders, development and systematic use of these tools will help capture the benefits of RTO co-operation for the Nations and to NATO.

The RTO is very focused on customer satisfaction, primarily that of the Nations. The RTO's broad spectrum of R&T activities has consistently attracted impressive participation from across NATO because of its value. Furthermore, the level of involvement of the Nations in RTO activities demonstrates the value that Nations find in this collaborative network. This satisfaction with the S&T deliverables has been clearly expressed by NATO and Nations in the DPPC(R)AR's report on the Science and Technology Reform of 3 June 2011.

Being concerned with its NATO customers, the RTO has made a concerted effort to maintain a close liaison with ACT, the NC3A and the NURC during the entire Reform period, with plans to continue this close relationship in the development of the S&T implementation plan. The NATO Reform Agenda has offered an unprecedented opportunity to strengthen mutual co-operation and dialogue among these and all members of the S&T community in providing a way forward to build the 21st century's shape of NATO S&T.

MEASUREMENTS OF VALUE

Value Added

Measuring the value derived by a Nation in participating in the RTO co-operative environment in a quantitative fashion is particularly difficult in the R&T domain. The advancement of knowledge, development of standards to enable interoperability, avoiding non-productive lines of research, and the successful accomplishment of mutually beneficial work produces obvious, but difficult to quantify economic benefit.

Strategic Assessment

Given today's context of the NATO S&T Reform effort underway and the resources required to develop and execute a true strategic assessment within a change environment, the RTB has chosen to focus its attention on implementing the S&T Reform before standing up that process. In the interim, indirect measurements are used such as participation trends.

Participation Trends

Nations demonstrate their dedication to the NATO collaborative environment through the participation of their technical experts in a variety of activities which provide for the exchange of information, the advancement of capabilities and the development of standards which enable interoperability. National participation varies broadly over time and is dependent on research topic and ability to start or align existing programmes for synergistic effect. In recent years, more than 140 activities continue to be supported each year, with a significant increase noted for 2012.

Improving Connectivity

A key expectation of the NATO S&T Reform process is a higher level of connectivity between stakeholders which would yield greater transparency, efficiency and effectiveness. In advance of the implementation of the new STO, the RTO has reached out to better engage with ACT in multiple fora; specifically in November at ACT HQ to discuss how best to improve the supply-demand relationship in the S&T context. Partners from the Nations and NATO entities were also recruited as key advisors for the S&T Reform Implementation Team in the development of an S&T response to the reform. Also stepped up was both formal and informal connectivity with NURC, CNAD, MC, NATO Consultation, Command and Control Board (NC3B) and the ESC Division.

Optimising connectivity between the S&T stakeholders within NATO and the Nations will allow the new STO to be a two-way portal for information exchange and the brokering of knowledge critical to the Alliance.

CUSTOMERS' CORNER – MEMBERS HAVE THE FLOOR

NATO HQ – Defence Investment Division

Mr. P. Auroy, Assistant Secretary General for Defence Investment and Chairman of DPPC(R)AR

"The RTO provides a network for Nations to collaborate on science and technology that is indispensible for the Alliance to achieve its objectives in defence and security. The results of this collaboration are directly relevant not only to the Nations, but to NATO defence planning as a whole. In close co-ordination with the Armaments and Command, Control and Communication (C3) communities, the RTO gives living proof of what "Smart Defence" means by facilitating and encouraging multi-national collaboration from the onset of capability delivery. I have every expectation to see this highly successful organisation strengthened even further in the course of 2012 through the implementation of NATO's Science & Technology Reform."

NATO Strategic Command

General Stéphane Abrial, Supreme Allied Commander Transformation

"The Research and Technology Organisation delivers highly valuable scientific and technological knowledge. Growing interactions between the scientific community and ACT's teams are a multiplier of their added value to NATO and Nations."

NATO Nation

MinRat Rainer Krug, German RTB Principal

"Co-operation in Defence Research is seen as an integral part of the national S&T Programme. International Co-operation in R&T projects comes prior to national investigations and allows for synergies. It is very valuable for Germany because, for example, in the vortical flows domain, recent RTO activities provided tremendous knowledge achievements due to a common integrated approach between experiment and computational simulation, expertise sharing among participating Nations, and cost reductions due to sharing of test data and wind tunnel models among Partners."

NATO Partnership for Peace Nation

Mr. Jan-Olof Lind, Director General FOI (Swedish Defence Research Agency), Sweden

"Sweden considers the RTO as a unique forum for multi-lateral co-operation, providing an excellent network for scientists. Mutual benefit is gained from its activities, which are also good education opportunities for young scientists. Conferences and seminars are first-class."

NATO Global Partner Nation

Mr. Peter Kerr, Counsellor Defence Science (London), Australian Defence Staff

"The Defence Science and Technology Organisation (DSTO) finds value in co-operating with the NATO R&T community. Benefits of its involvement originate from the following RTO characteristics: the RTO programme of work is very much outcome driven; the RTO provides a richer scientific community; and RTO meetings are attended by practitioners."

FACTS AND FIGURES

People

The RTA workforce consists of a combination of military and civilian Staff of multiple NATO nationalities, with different backgrounds and different status. About one third are NATO International Military Personnel (IMP) voluntarily contributed by the Nations – the others are NATO International Civilians (NIC). The pie chart below shows the detailed distribution of the 58 posts of the Peace-time Establishment (PE) – five are vacant; two have twin functions.

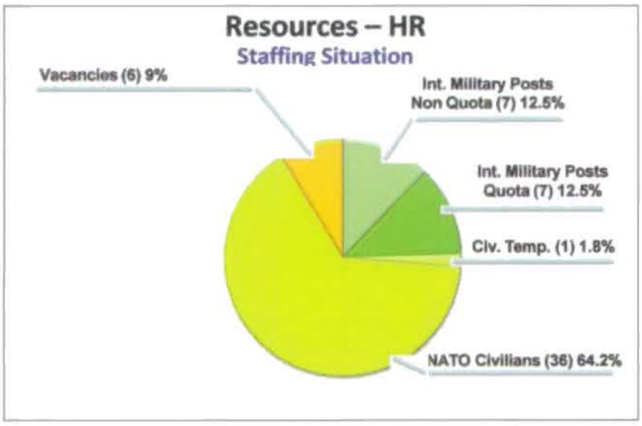

Figure 45: RTA Workforce.

The IMP positions, at the post-graduate level, are directed at the support to the Scientific Panels; they are vital to the execution and continuous monitoring of the RTO PoW. The NICs are employed in support and services functions.

Globally speaking, the personnel situation is sound. Nations continue to send their best to properly man the RTA.

The support for the NATO Modelling and Simulation Group asked for particular attention. The RTB took action by planning a dedicated event to discuss the future of Modelling and Simulation in NATO in the margins of the Spring 2012 RTB.

The on-going NATO Agencies Reform influenced the 2011 personnel situation of the Agency (recruitment freeze).

Preparations for the definition of the PE in the STO structure started in 2011, taking into account the Ministerial guidance to preserve the level and quality of the executive support provided to the execution of the programme of work.

That new PE will be influenced by the stand-up of the Office of the Chief Scientist, the decision pertaining to the NATO Shared Services and the savings' objectives.

Budget and Finance

The RTA is principally funded by the Military Budget Committee (MBC) under the International Military Staff (IMS) Budget Group. The personnel and operations of the RTA Brussels component are funded from the Civil Budget as part of the International Staff (IS) Budget.

The funds for their R&T-related activities are delegated to the RTA for management and execution; this is done in close co-ordination with the IS Financial Controller's office. In addition, the RTA also has a delegation of funds from the IMS for its PfP and MD activities. The financial activities of these programmes are also managed by the RTA under the supervision of the IMS Financial Controller's office.

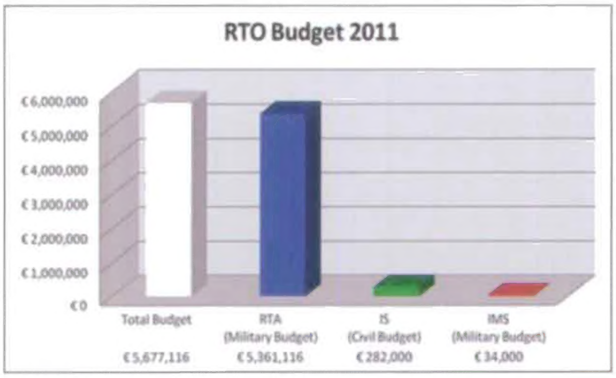

Figure 46: A Brief Overview of the 2011 RTA Finances (in k€).

For all financial operations of the Military & Civil Budget funds, the RTA uses the NATO Automated Financial System (NAFS) which has been in use at the RTA since the Fall of 2003. The RTA, as with the rest of NATO, has started to account for its financial activities according to the International Public Sector Accounting Standards (IPSAS) and has prepared financial statements according to these standards since then.

The Agency continues to strive for improved efficiency in conducting its work programme and other areas. Savings have been achieved over recent years in publications due to the move to electronic publishing. The extension of the RTO's data-base capabilities now enables on-line registration for RTO events and therefore on-line management of the processes. However, some of the savings have been offset by the need for more ADP investments in terms of both equipment and security measures.

The change in arrangements to encourage RTO Technical Teams of all kinds to hold their meetings at the RTA has contributed to achieving savings in both travel and interpretation costs.

Furthermore, contracting efforts have led to efficiencies in various areas throughout the budget, providing the RTA (and the RTO) with more value for money and assisting in conducting different operations even more effectively.

The International Board of Auditors for NATO (IBAN) audited the RTA 2009 Financial statements and issued an "unqualified" opinion on these accounts in January 2011.

The audit of the 2010 accounts by the IBAN was conducted in October 2011. The final audit report has not been issued by IBAN at the time of this annual report.

Collaborative Environment

Fundamental to the functioning of the RTO is a secure collaborative environment. The web-based environment forms the backbone of the operations of the RTO and has been developed through large-scale collaboration between the RTA and the RTO Community.

The RTO website has been recently upgraded to provide a more modern and corporate (NATO) look and feel. Traditional services like access to RTO activities and event information and the downloading of RTO (and AGARD) and NURC scientific publications continue to be used extensively. Additional services that are available include the streaming of RTO educational activities and the ability for RTO National Co-ordinators to appoint scientists to activities using an on-line interface.

Further, the SharePoint collaborative workspace (MyRTO) continues to provide a secure remote environment for the R&T community. At the time of writing, there are over 3300 users, mainly scientists, working across 300+ collaborative workspace environments. The current capabilities include file management, messaging, discussions and wiki-based services.

Internally at the RTA, many improvements have been made to the Information Technology (IT) infrastructure that supports these and other services. These improvements are mainly in the area of enhanced security and efficiencies made possible by virtualisation.

The Programme of Work

In 2011, 2786 participants participated in RTO activities. From these, 2554 were from NATO Nations, the rest (232) coming from Partner Nations. This figure was roughly the same as for 2010, demonstrating a consistent level of interest from Nations in the activities of the RTO.

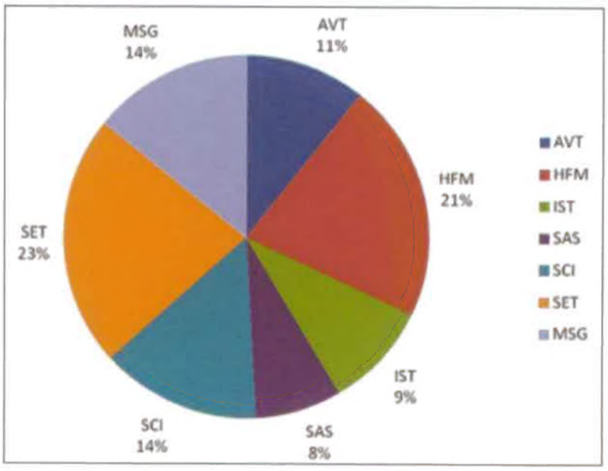

Figure 47: Distribution of Activities by Panel.

In total, the PoW consisted of 172 on-going activities, which is an all-time high for the RTO. From these, a total of 70 scientific publications were produced in 2011, again an all-time high for the organisation.

This trend is remarkable, especially in times of austerity. An analysis of these figures shows that Nations are more selective in the definition of their participation (sending less people to the activities), but that overall participation tends to increase.

As can be seen from the chart in Fig. 48, participation continues in all the elements of the spectrum of activities.

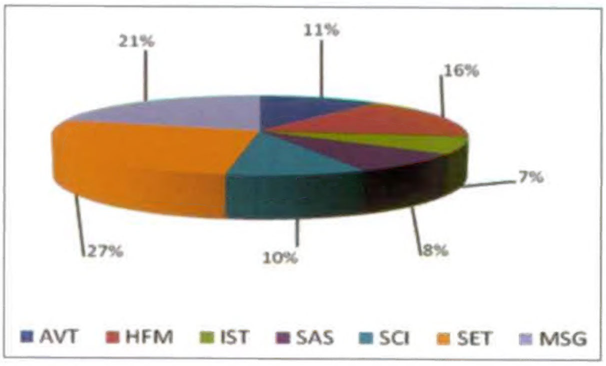

Figure 48: Percentage Spread of Participation in the Activities of the RTO.

Research and Technology Agency
B.P. 25, F-92201 Neuilly-sur-Seine Cedex, France
Website: www.rto.nato.int
Email: mailbox@rta.nato.int